NOVEMBER 1959

Agricultural Engineering

The Journal of the American Society of Agricultural Engineers

CASE HISTORIES

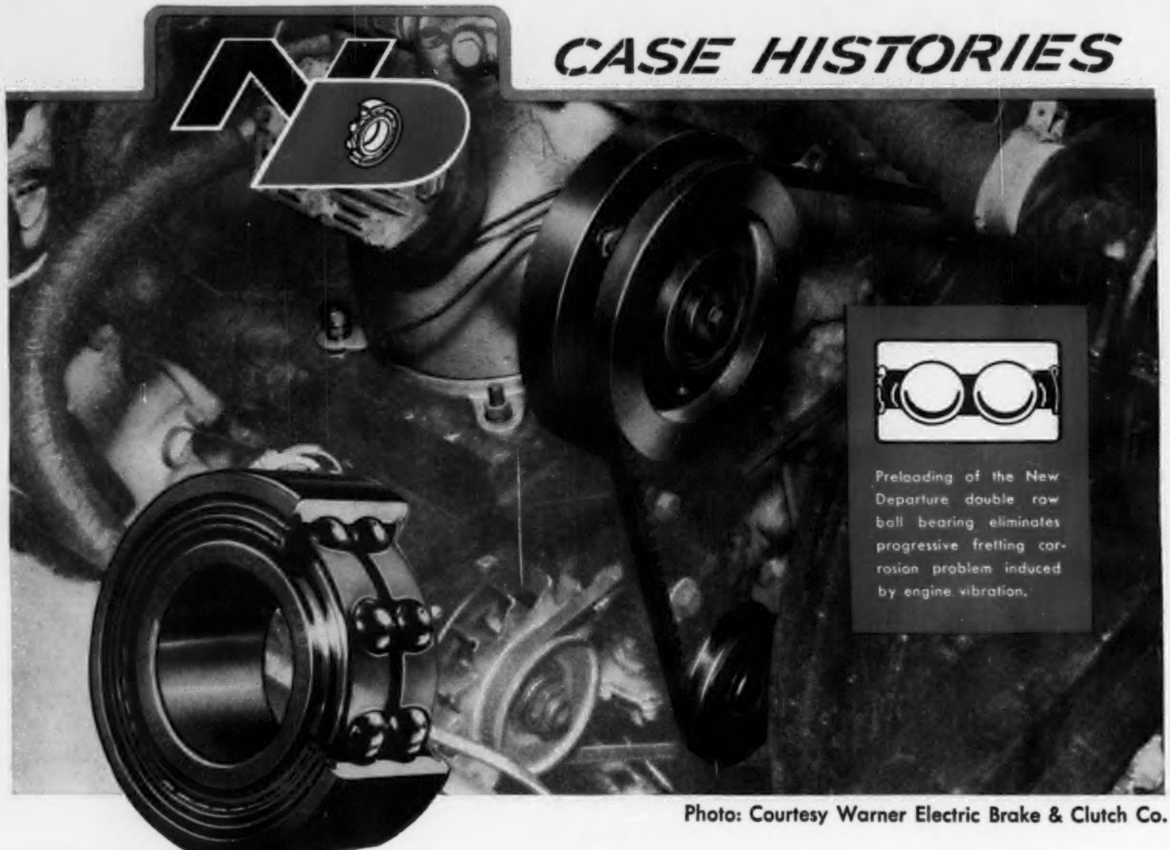

Photo: Courtesy Warner Electric Brake & Clutch Co.

Preloaded Double Row Bearings Solve Fretting Corrosion Problem In Electric Clutch!

CUSTOMER PROBLEM:

Fretting corrosion of automobile air conditioner electric clutch bearings due to engine vibration. Application requires compact bearing design and positive lubricant sealing.

SOLUTION:

N/D Sales Engineer, working with the manufacturer, suggested replacing two single row bearings with one internally preloaded New Departure Double Row ball bearing with shield and Sentri-Seal. The preloaded angular contact construction of these New Departures offered maximum resistance to combined radial and thrust load deflections, plus freedom from effects of engine vibration. Problem of fretting corrosion was eliminated by producing bearings with accurately determined internal compression. Lubrication of bearing was assured for life by New Departure's exclusive Sentri-Seals . . . dirt was sealed out under extremely contaminating conditions. In addition, the compact size of these double row bearings eliminated a tough assembly problem . . . and provided savings in both space and costs.

When you're faced with a bearing problem, why not call on New Departure. Chances are there's a precision N/D high production bearing that will solve it. For more information, write New Departure Division, General Motors Corporation, Bristol, Connecticut.

Replacement ball bearings are available through United Motors System and its Authorized Bearing Distributors.

NEW DEPARTURE

BALL BEARINGS

proved reliability you can build around

Agricultural Engineering

Established 1920

CONTENTS • NOVEMBER, 1959 • Vol. 40, No. 11

Note: AGRICULTURAL ENGINEERING is regularly indexed by Engineering Index and by Agricultural Index. Volumes of AGRICULTURAL ENGINEERING, in microfilm, are available (beginning with Vol. 32, 1951), and inquiries concerning purchase should be directed to University Microfilms, 313 North First Street, Ann Arbor, Michigan.

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JAMES BASSELMAN, *Editor and Publisher*

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Motion Picture Progressometer

DURING the Winter Meeting of ASAE held in Chicago in December 1958 a goal and target date for completion of an ASAE motion picture were established. A contract had been signed with the Motion Picture Service of the U.S. Department of Agriculture to supervise production of film, supply technical advice for shooting and production and exercise full responsibility for making a 13½-minute movie in full color and sound. Purpose of the film is to acquaint high school students possessing engineering aptitudes and an interest in agriculture with the challenges and opportunities offered by the profession of agricultural engineering.

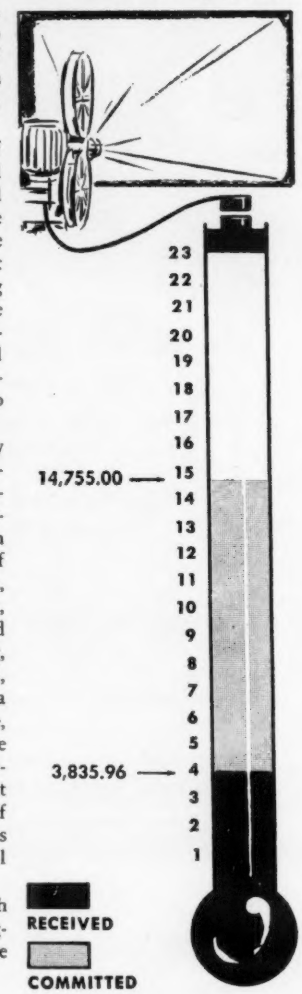
Filming of the picture is now under way and copies have been promised by June 1960. The goal of $23,000 was established by the ASAE Motion Picture Production Committee as necessary for completion of the project. Funds to meet the goal are anticipated from four major sources, all of which have a vital stake in agricultural engineering: (1) college agricultural engineering departments; (2) ASAE sections; (3) industry; and (4) selected individuals.

In the October issue of AGRICULTURAL ENGINEERING a Motion Picture "Progressometer" was introduced to keep members of ASAE, and others interested in the project, informed of its progress. In October total cash received amounted to $2,533.81 and commitments totaled $13,405.00. During the past month cash received has increased to $3,835.96, an increase of $1,302.15, and commitments increased to $14,755.00, an increase of $1,350.00.

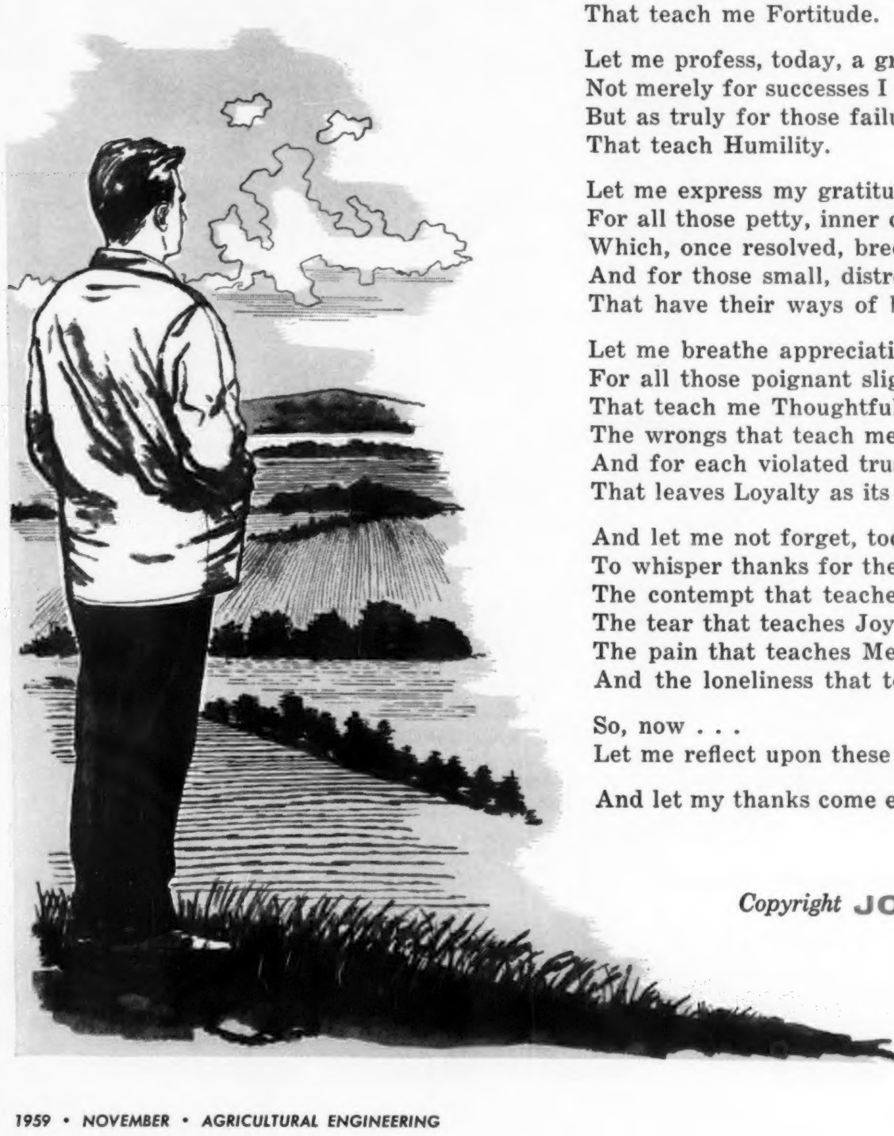
During the month of October two additional ASAE sections completed payment on their respective quotas. Latest to join the paid-up Sections are Pacific Coast and Florida, bringing the total to 12. Also, since the Florida Section oversubscribed its quota, the total of Sections that oversubscribed has been increased to seven.

As reported in the July issue the category for contributions for college agricultural engineering departments, under the direction of A. W. Farrall, head of agricultural engineering, Michigan State University, and A. J. Schwantes, head of agricultural engineering, University of Minnesota, has exceeded its quota by a total of $1,500.00. To date, 26 copies of the film have been ordered. Since payment, in most cases, cannot be made until delivery of film is made this represents a large portion of the total shown as committed.

Watch this column each month to observe the progress of the Motion Picture project.



My thanks come easily at Times...



My thanks come easily
When my fortunes rise
And my will is king
And all the world seems my estate.

My thanks come easily such times.

But, wait . . .
Today, let me reflect
Upon those thanks I owe
But which I find
Express themselves less fluently.

Today, let me remember to give thanks,
Not only for the sunlight,
But for those darker hours
That teach me Fortitude.

Let me profess, today, a grateful heart,
Not merely for successes I may know,
But as truly for those failures
That teach Humility.

Let me express my gratitude
For all those petty, inner conflicts
Which, once resolved, breed new Serenity . . .
And for those small, distressing fears
That have their ways of building Hope.

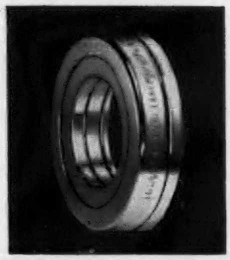
Let me breathe appreciation
For all those poignant slights
That teach me Thoughtfulness,
The wrongs that teach me Fairness,
And for each violated trust
That leaves Loyalty as its lesson.

And let me not forget, today,
To whisper thanks for these:
The contempt that teaches Pity,
The tear that teaches Joy,
The pain that teaches Mercy,
And the loneliness that teaches Love.

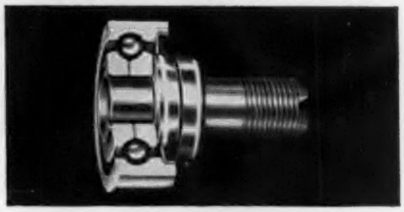
So, now . . .
Let me reflect upon these thanks I owe . . .

And let my thanks come easily today!

JOHN DEERE

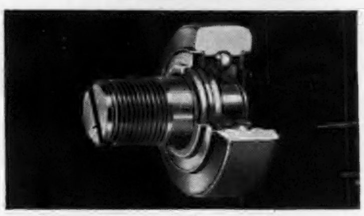


Clutch Bearings



Hay Rake Bearings

Idler Pulley Assemblies



Plunger Rollers

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You simplify production line installation and reduce manufacturing costs with "package units" designed and produced by BCA—the company that conceived and developed the ball bearing "package unit" idea. Bearing, housing and seal are combined in one rugged unit lubricated for life and sealed against water, dust and grit. BCA "package units" are available for a very wide range of applications including hay rake bearings, idler pulley assemblies, clutch bearings and plunger rollers. Count on BCA experience to provide ball bearing "package units" that are right for you and your customers . . . whether the application is unusual or routine. Bearings Company of America Division, Federal-Mogul-Bower Bearings, Inc., Lancaster, Pa.

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DIVISION OF
Federal-Mogul-Bower Bearings, Inc.

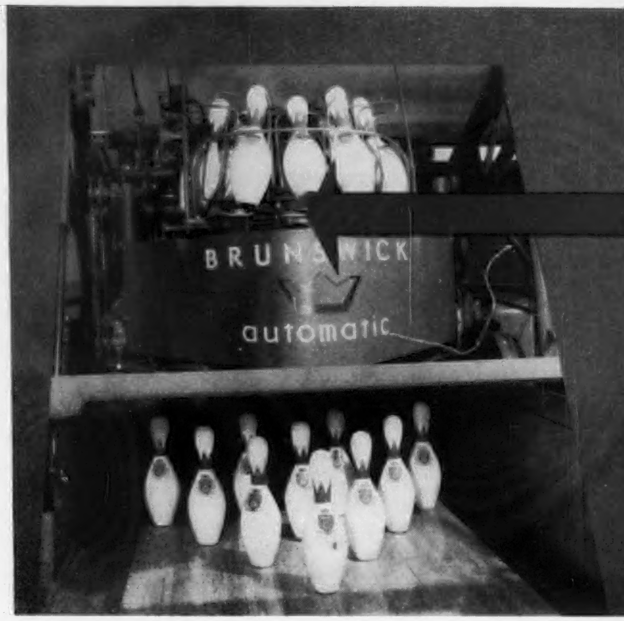
Report to Readers . . .

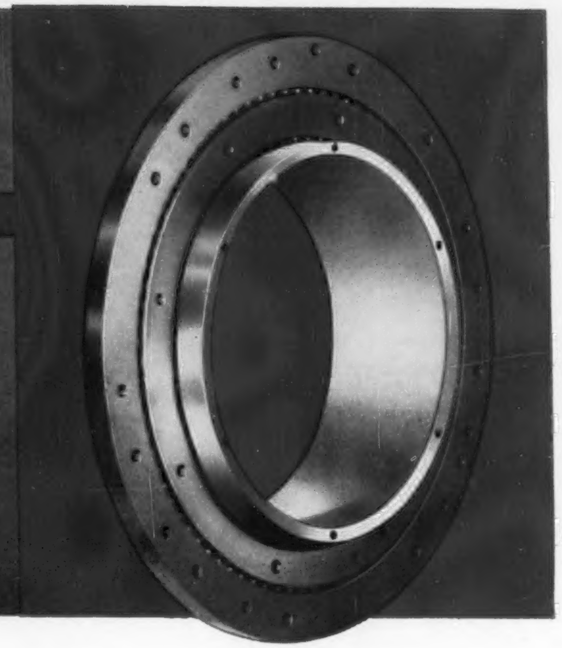
CHEMICALS MAY REPLACE HAND LABOR FOR CONTROL OF WEEDS IN PRODUCING COTTON "Chemical control of weeds has made possible a greater reduction in the cost of producing cotton in some areas than any other development during the past 50 years. In fact, it is not too difficult to believe that, within the very near future, hand labor for removing weeds in cotton on mechanized farms will no longer be needed." . . . . That statement summarizes the opinions of a research team – an agricultural engineer and a plant pathologist – based on their field studies at the Louisiana AES and reported at the 1959 ASAE annual meeting. . . . . Chemical control of weeds in cotton, say these researchers, is fast becoming a common sight in some areas of the cotton belt. Applications of pre-emergence herbicides are made (separate from planting) with a single, flat fan-type nozzle (of 0.3 to 0.5 gpm capacity) mounted directly behind each planter press wheel. For post-emergence applications, flat fan-type nozzles with a discharge capacity of 0.05 to 0.10 gpm are used. . . . . For applying herbicides at the last mechanical cultivation of the crop, high-clearance sprayers are used with one or two nozzles to direct the spray solution over the entire area between the rows of cotton. Off-center flat fan and flooding-type nozzles have been used successfully for this application in which 15 to 30 gallons of spray material are applied per acre. These lay-by applications are becoming increasingly popular since they decrease the number of mechanical cultivations needed and help provide weed-free cotton to facilitate mechanical harvesting.

IRRIGATION GOES UNDERGROUND AND CUTS EVAPORATION LOSSES A California engineer, after several years of research and experimentation, has developed a new irrigation system which he believes will practically quadruple a farmer's available water supply. The basic feature of this system is a ceramic container, or "wick," to which irrigation water can be fed by plastic pipes placed at intervals underground. . . . . Development of the wick is a new application of the law of capillarity and is the result of extensive experimental work with various materials to produce a wick that will give precisely the right porosity. Successful applications of the new system have been made to the irrigation of grass and row crops and slopes, and further research is to be made on its adaptability in general agriculture. Research results thus far indicate that the wick system requires about one-fourth as much water as would be needed by the furrow system. Moreover, not only evaporation but also runoff, seepage and deep percolation losses are eliminated. Another advantage claimed for the new system is in the application of liquid fertilizers and of chemicals for the control of plant pests and diseases.

ENGINEER STUDIES PERFORMANCE OF MECHANICAL SILO UNLOADERS Not many pieces of mechanized farm equipment are more welcomed by farm workers than the mechanical silo unloader. A wide variety of unloaders has been developed and offered to the farm trade. . . . . But removing silage from a silo, either manually or mechanically, is not a simple operation. Some real problems are involved in developing a mechanical device that will satisfactorily meet operating requirements. It is by reason of this fact that a USDA agricultural engineer was assigned to a study of the problem at the Minnesota AES. Several types of loaders have thus far been studied. These studies showed that unloading time varied widely. For example, using a 3-hp unit in a 14-foot silo, the rate of unloading varied from 80 to 180 pounds of silage per minute. An important requirement for best operation of the mechanical unloader is that the silo interior be a perfect circle. . . . . One of the main obstacles to the successful use of the silo unloader was found to be frozen silage. This condition was most prevalent where moist air from the barn entered the silo, and to overcome it the engineers recommend installing an exhaust fan in the dairy barn.

(Continued on page 648)





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Quick, dependable performance is the key to the success and widespread adoption of the Brunswick Pinsetter. It must function perfectly, steadily, accurately—game after game, day and night—without maladjustment, breakdown or delay—and it is in just such service that Aetna Bearings prove their stamina, perfect workmanship, accuracy and dependability. Despite the fact that the pins vary slightly in weight, the Pinsetter continues to perform smoothly and accurately on its main Aetna Bearing which remains in correct alignment at all times and operates quickly, smoothly, unfailingly load after load.

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RESEARCH TEAM SPECIFIES EQUIPMENT FOR CHEMICAL CONTROL OF NEMATODES

A California AES research team – a nematologist and an agricultural engineer – reported recently on a study of special interest to research and development engineers because of the emphasis on equipment requirements resulting therefrom. . . . . Equipment for applying nematocides follows the general design of pesticide sprayers, dusters and granule applicators; it is similar also to devices for applying fertilizers. The one important difference that exists – and that greatly alters the equipment requirements – is the very low application rate at which mematocides are applied, 3 to 20 gallons per acre being the usual application, depending on material used and plants treated. These low application rates require precision metering equipment and careful calibration. . . . . While dusts are used but little for nematocide formulation, granulars made up in the usual size range of 15 to 60 mesh have been found satisfactory for many applications. The advantage of granular materials is that they are more easily handled than liquids, are less volatile, and lend themselves to low metering rates. The usual fluted-feed seeder device, augers, chain feeds, endless belts, revolving plates and simple paddle-over-orifice systems will handle rates as low as 2 pounds per acre at 12-inch spacing. The endless-belt and double-revolving-plate types have perhaps the greatest accuracy of the several systems. Since fertilizers and nematocide materials are now made up in granular combinations, the California researchers recommend any of the better fertilizer-type metering devices as suited to these materials, the revolving plate, endless belt, and simple agitator over orifice being in common use.

COORDINATING WEATHER DATA WITH THE DRYING OF GRAIN

Missouri AES agricultural engineers have developed a method by which weather data can be processed to yield information in connection with two phenomena associated with grain drying, namely, (a) the average Btu per pound of air available for drying a grain mass of known moisture content and (b) the average temperature of the portion of the grain mass that would be the last to dry if the air were forced through the mass. The method is based on the development of mathematical models that can be programmed on modern electronic calculators. The data put into the machine consist of hourly readings of wet and dry-bulb temperatures. . . . . The study considered six levels of "equilibrium moisture content," which is defined as the ratio of the vapor pressure of the moisture in the grain to the vapor pressure of pure water at the same temperature.

EFFICIENCY OF HAY DRYING IN TERMS OF HAY CONSUMED AND MILK PRODUCED

"Hay harvested at the best stage of maturity and then barn-dried will, when consumed, produce 2000 to 2800 pounds of milk for every ton of hay eaten." That statement was made recently before an ASAE meeting; it also assumed a specified harvesting procedure: cutting and crushing in the forenoon, raking at midday while the leaves were still damp and tough, baling or chopping about midafternoon with moisture at 35 to 45 percent, and drying overnight on wagons with heated air or in the mow with natural air. . . . . The point was made also that milk production from hay fed to cows is reduced 10 to 12 pounds per day for each week cutting is delayed after June 6 (in the US northeast), and the best second cutting is not as good as the first cutting before June 10. . . . . If hay is cut at the right stage of maturity and barn cured, it can produce a larger return per acre, when fed to dairy or beef cattle, than a crop of corn, wheat, oats, soybeans or other small grains. . . . . The speaker further contended that barn hay-drying equipment is twice as profitable an investment as a bulk milk cooler, which has already proven to be a good investment for thousands of dairy farmers. It was further stated that where the installation of a bulk milk cooler has increased farm income $3 to $4 a day, an equivalent investment in a hay-drying installation would result in an extra income of $7 to $10 per day.

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big lift!

Powerful IH tractors have the sure-traction and big hydraulic "muscles" to load and haul record manure tonnage

Slam an IH tractor and its brawny loader into hard-packed manure to cram the fork full when others can't. Feel how big power, big wheels, and balanced weight give you sure-traction even in slippery lots. Smooth, peppy IH engines, that seem to "see" the load coming, power you through tough spots where others slow or stall.

"Live" hydraulic power keeps raising loader fork as you clutch or shift to shorten the loading cycle. This high-volume hydraulic power gives McCormick® loaders tremendous break-away lift . . . helps you load big spreaders minutes faster. You power-steer your way in and out of tight spots and across deep ruts with one-handed ease. And faster tractor speeds and bigger-capacity McCormick spreaders help you spread tons more manure in a shorter day!

Clean low sheds and tight corners easily with low-profile International® 240 Utility, and close-coupled McCormick No. 20 loader. This rugged loader lifts 900 lb . . . dumps fork clean at nearly 8-foot height. Tidy up quickly with handy rear blade. You control this blade precisely with Tel-A-Depth.

Power-load a 95-bushel spreader in a hurry with this International 340 Utility tractor and a McCormick No. 34 loader. Even in cramped and muddy lots, IH power steering, 2-way control of bucket and boom, and optional Fast Reverser cut loading time way down to help you move tons more manure daily.

Haul more loads in a day with faster transport speeds. Torque Amplifier drive gives Farmall tractors two road speeds. You can start a heavy load like this 95-bushel McCormick No. 31 spreader in 5th-TA, and when the load is rolling, *instantly* step up to 16½ mph without shifting gears.

Power-away your loading and hauling jobs fast with IH tractors and McCormick equipment to gain extra field time worth hundreds of dollars. See your IH dealer for more facts, and a good deal!

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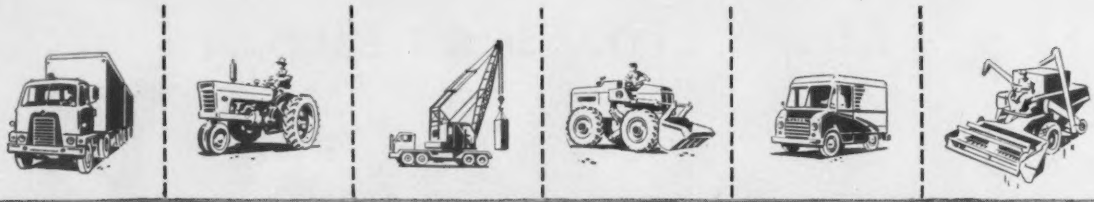

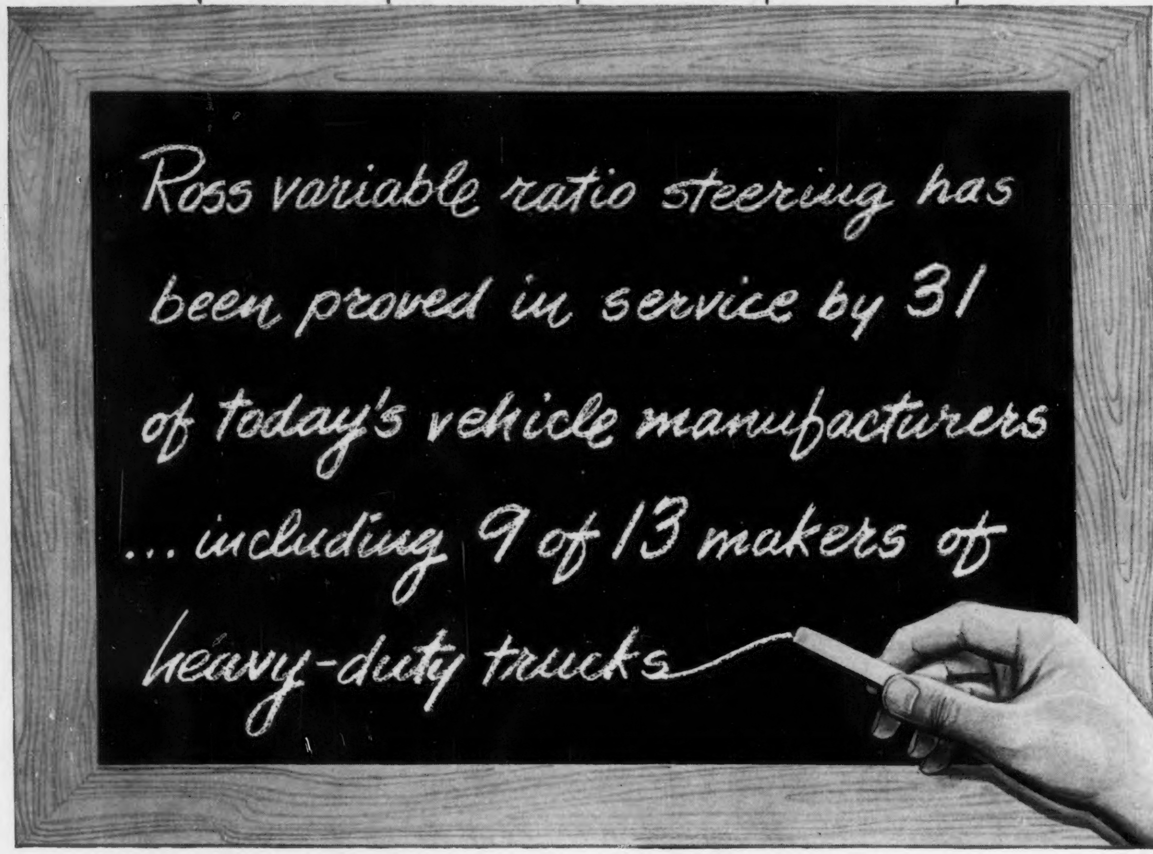

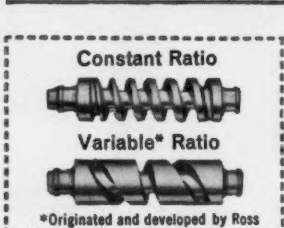

● Ross variable-ratio steering gives faster steering and quicker recovery for turns . . . and slower steering and greater stability for straight-ahead handling. Ross invites *your* inquiry.

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LUBRICATES ALL BEARINGS IN SECONDS!

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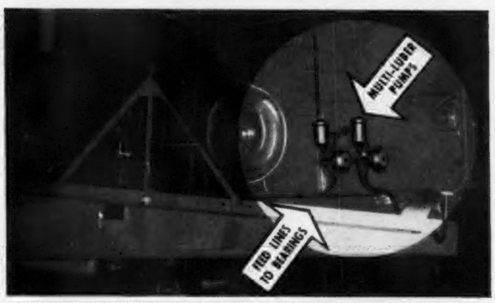

By designing this low cost, automatic lubrication system into your farm implements, you automatically increase their efficiency, economy, service-life, and sale-ability. Here's how Lincoln MULTI-LUBER Systems pay off:

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3. Prevent breakdowns before they start—win dealer and customer satisfaction.
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5. Prevent waste and contamination of lubricant. System is completely sealed.
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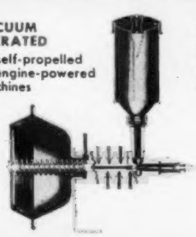
on self-propelled or engine-powered machines



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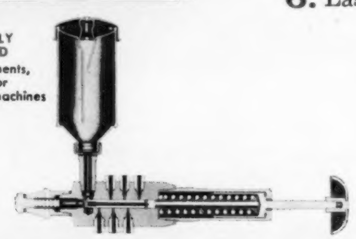

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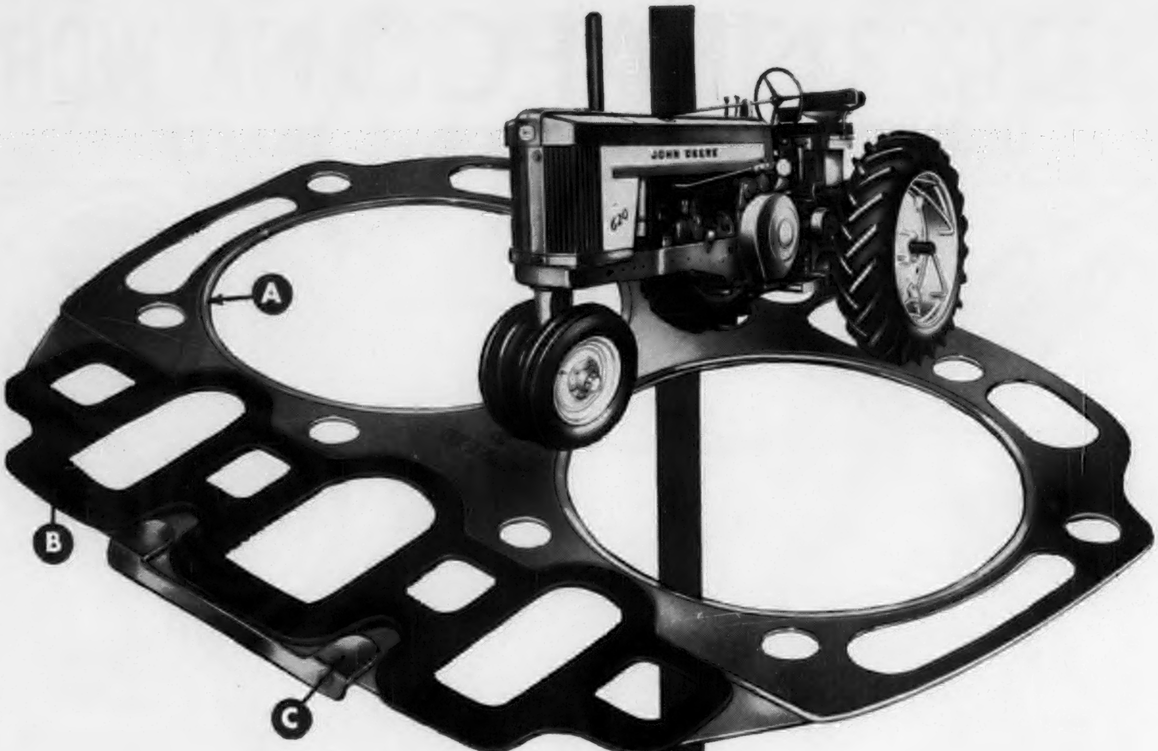
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620
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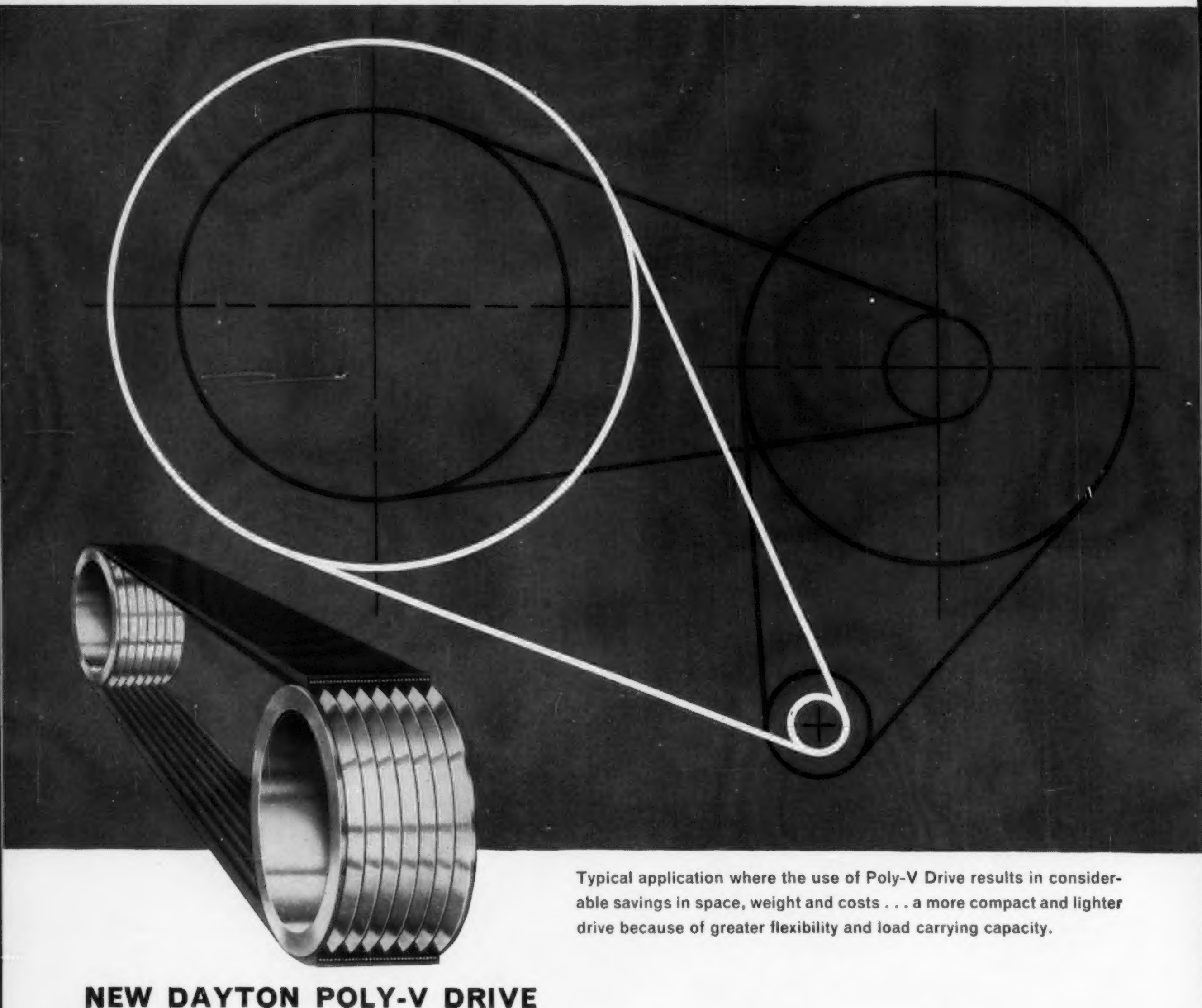
New DAYTON POLY-V® DRIVES permit



Typical application where the use of Poly-V Drive results in considerable savings in space, weight and costs . . . a more compact and lighter drive because of greater flexibility and load carrying capacity.

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New Dayton Poly-V Drives complete the Dayton line . . . answering many of the design engineers' problems dependent on greater power delivery under the most critical space limitations.

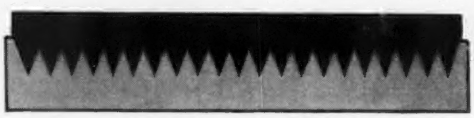
This new concept of power transmission employs a single, endless parallel V-ribbed belt running in sheaves designed to mate precisely with the belt ribs. Single unit design provides twice the tractive surface per inch of sheave width . . . delivers up to 50% more power in as little as ⅔ the space where these requirements are indicated. This means *less* overhang, less bearing load . . . a more compact and lighter drive. Single unit design completely eliminates need for matching belts, helps maintain constant pitch diameter and speed ratios from *no* load to *full* load. You get longer drive life . . . smooth vibration-free performance . . . greater dependability . . .

Service . . .

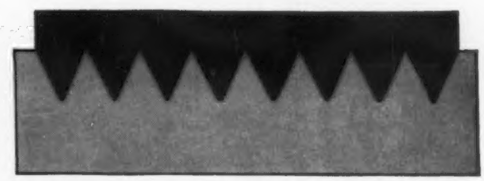
wide range of special drive designs . . .

provide for more power in less space

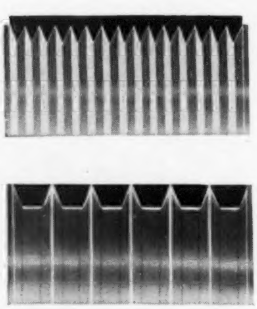
Now from one source, Dayton Industrial Products Company—the most complete line of friction-type drives in existence—for every application from automatic washers and dryers to large industrial machinery and farm implements.



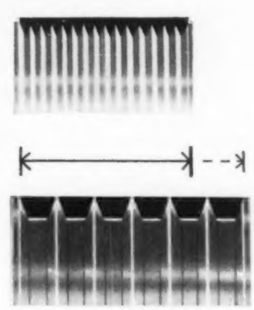
Gives Greater Power Capacity. Full contact with the entire sheave driving surface gives Dayton Poly-V greater power capacity because it has twice the contact area of other drives with half the surface pressure.



Maintains Constant Pitch Diameter at All Loads. Full contact of Dayton Poly-V gives solid support under strength member. Speed ratio doesn't vary. Belt position remains constant from no load to full load.



Delivers More Power. Dayton Poly-V increases the drive capacity 30% to 50% in the same drive width . . . functions as a friction-force-multiplier in the sheave groove. Makes Poly-V ideal where more compact design is essential. Three cross-sections (J 3/32", L 3/16", M 3/8" rib widths) handle all applications.



Saves Space. Narrower drives deliver equal power in less space. In most applications, the width of Dayton Poly-V Drive is 2/3 to 3/4 of the width of standard multiple drives of the same horsepower. Poly-V has higher horsepower capacity per inch of sheave width. Means less shaft overhang, less drive weight, lower drive cost.

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Make use of Dayton's special Drive Engineering Service when you think of power transmission. The time to call us is when your design is still on the drawing board. We have *no axe to grind*—we'll help you select the Dayton V-Belt Drive (FHP, Multiple Variable Speed or Poly-V) best suited to your specific need.

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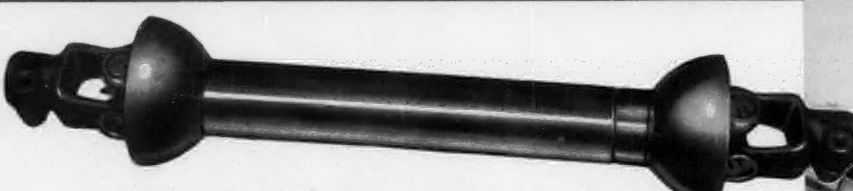

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SYSTEMS ENGINEERING IN AGRICULTURE

Guest Editorial by L. L. Sammet

Member ASAE

THE systems concept, which views any complex entity or process in terms of the functions, interrelationships, and integration of its parts in a unified whole, is not new. This was an important element in early developments in astronomy, in physics, and in the plant and animal sciences. On it rests the long-established tenet of functionalism in architectural design. It is a matter of achievement in many different man-made, controlled systems. Among the latter, our highly complex telephone and railroad systems, industrial production systems, and missile and defense systems are impressive examples.

While the systems concept and significant accomplishments in the creation of man-made systems—as distinguished from natural systems—are well established, interest in systems and *systems engineering* is at a new and rising level. In many instances, this is a necessary adjunct of the system itself. The value of a telephone system, for example, rests on its flexibility and capacity for associating and integrating countless numbers of component parts. Attention to components integration—a systems view—in this instance is virtually forced. Similarly, the design and assembly of components that will automatically coordinate functions of search, tracking, launching, and guidance of a military missile cannot be visualized outside a framework in which the interaction and integration of correlated members—the essence of systems design—is a major concern. A systems view is equally essential in the design of an automated factory. The nature of such processes makes close attention to systems design inescapable.

Many processes with systems attributes, however, lack features that compel attention to systems design. The process may, for example, be composed of many highly correlated members yet not be rigidly controlled from a single point. To a degree its components may be flexible and adaptable. Or there may be a substantial time lapse between successive operations. In these circumstances, acceptable performance may be possible despite serious imperfections in the integration of components in a unified system. This allows engineering effort to focus on design and performance of components. Systems implications may be recognized but not stressed. This is the situation with respect to many types of manufacturing, in the distribution of commodities, and in agricultural production.

Even in the less closely knit processes, however, growth of interest in the systems view seems certain. Contributing to this trend is increasing specialization encountered throughout industry and agriculture. This applies to the nature of the jobs of individual workers and the equipment they use as well as to the technicians responsible for methods and equipment development. As jobs become more specialized, there are more identifiable process steps and so greater need to consider the implications of interdependence between them. As we advance in technology and technique, more alternatives in type of equipment and method of performance become available. With increasing specialization, greater interdependence, and more alternatives in the means of production, there is greater need for selection of the "best" of alternative techniques in particular process steps and for their coordination in integrated processes. Increasing scale of individual business units provides improved opportunities for conducting systems studies and acting on their results. The strengthened interest in systems which follows these developments has been reinforced by the development of—and publicity for—new problem-solving techniques; for example, new methods of mathematical programming, new theories relating to "queuing" and "games" applicable in some aspects of studies of organization, and improved electronic computers and programs for their use.

In the business world and among the sciences on which it draws, the growing interest in studies of systems organization has been formalized. New fields are being or have been defined. There are, for example, new fields described as "management science," "operations research," and "systems engineering." There are new professional groupings, societies, and periodical publications*.

Of late in agricultural engineering the systems concept is receiving explicit and growing attention, and a recent issue of *Agricultural Engineering* is liberally sprinkled with references to this idea†. These developments, however, are informal and preliminary. They leave the central question for agriculture one of direction, emphasis, and methodology. Are there opportunities, either neglected or already being realized, for agricultural engineering in this field?

A Place for Systems Engineering in Agriculture

If defined very generally as "an assemblage or set of correlated members," systems are easily discovered in agriculture. Processes with this attribute are provided by nature, and so systems in agriculture could be claimed to exist from the beginning of this industry. A significant role for engineering, however, depends on the existence of desire and means to modify natural processes and to control environmental factors in livestock and crop production and in crop storage. Both desire and means are evident in the abundance of equipment, materials, and methods that have been developed for use in farm production. Viewed narrowly, many single units of equipment are sufficiently complex in themselves to qualify as "systems." A farm tractor, for example, can properly be described as a complex, unified system for converting liquid fuels to mechanical power. With its integrated assembly of tillage and other tools, it becomes a vital element in a still larger scheme.

This larger scheme is exemplified in the production and utilization of forage crops. Here is a system comprised of major subprocesses or stages—soil preparation, planting, harvesting, transporting, storing, handling, and feeding, in which the tractor-tool unit serves not as a "system" but as a tool‡. Each stage involves numerous separate operations and the functioning of many individual components. Among both components and stages will be found interdepend-

(Continued on page 685)

Paper presented at the Winter Meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 1958, and submitted for publication as Giannini Foundation Paper No. 183.

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Acknowledgment: The author gratefully acknowledges the contributions of several critics of this paper, in particular that of Harold E. Pinches, who read and commented freely on several versions of it.

*For example, the journals of the Operations Research Society of America and of the Institute of Management Science.

†Pinches, Harold E., AGRICULTURAL ENGINEERING, Vol. 37, No. 11, November 1956), p. 747, and Vol. 39, No. 9 (September 1958).

‡Systems and their components can, of course, be variously defined. In this discussion, a "system" is very generally defined as a complex entity composed of numerous interacting and integrated members. Within a given system, relatively large aggregations of parts constituting "subsystems" may be identified through which given processes involved in system performance are accomplished. Such subsystems may in turn be composed of a series of closely coordinated process stages—each stage involving the coordinated performance of a group of discrete tasks defined here as "operations".

Hay Conditioning Methods Compared

M. M. Boyd
Assoc. Member ASAE

Field tests compare drying rate and field loss of smooth-roll crusher corrugated-roll crimper, and flail-type forage harvester

SINCE the leaves of hay dry more rapidly than the stems, by the time the stems have reached a moisture level sufficient for storage, the leaves have been overdried. This excessive drying of the leaves only serves to increase shattering losses in subsequent operations.

A great deal of progress has been made in recent years in the development of forage conditioners. These machines crack the hay stem exposing more area for moisture loss and thus speed the field-curing rates of forage crops.

The present commercial conditioners may be put into two general classifications: the corrugated roller and the smooth roller. The corrugated-roll machine is commonly referred to as a crimper, while the smooth roll machine is called a crusher. Both machines will pick up a swath and pass it between their rollers thus cracking, and/or crushing, the stems in the process. Both classes generally provide some means of adjusting the pressure exerted on the hay by the rollers. The basic difference between the two concerns their crushing action. The crimper, because of its corrugated rolls, cracks the stems at regular intervals while the smooth-roll unit crushes the stem along its entire length.

In addition to the more common hay conditioners, some interest has developed in the use of flail-type forage harvesters in haying operations. This machine, though it cuts a narrower swath than conventional mowers, appears advantageous from the standpoint of effectively combining the mowing and conditioning in a single operation, thus reducing operating time while speeding the drying rate.

Description of Machines

A single model of each the smooth-roll crusher, the corrugated-roll crimper, and the flail-type forage harvester were used in the tests discussed in this paper.

The smooth-roll crusher consisted of two large 12-in.-diameter steel rollers for crushing the hay. The rollers are 80¼ in. long, the upper one being loaded through springs located at either end. The springs provide the crushing pressure as well as allowing separation of the rolls when heavy wads of hay are encountered. The pickup on this machine consisted of a small-diameter slatted cylinder.

The crimper had malleable-cast iron rolls with tapered flutes. Roll length is 72 in. Springs hold the upper roll against stops so as to limit the amount of overlap between roll flutes to about ⅝ in. The lower roll on this machine serves as its pickup.

The flail harvester consists of a horizontal shaft oriented normal to the travel direction on which are hung a series of pivoted, L-shaped steel flails. The width of cut is 5 ft. The machine was operated at minimum cutting height with the rear opened to allow cuttings to fall back on the ground.

Paper presented at the Annual Meeting of the American Society of Agricultural Engineers at Ithaca, N. Y., June 1959, on a program arranged by the Power and Machinery Division.

The author — M. M. BOYD — is instructor in agricultural engineering, University of Massachusetts.

Experimental Procedures

The following paragraphs are devoted to a discussion of the procedures used in determining the effects of the different conditioning methods on field curing rates.

Each field in which tests were made was divided into four equal portions. Each of the four plots was allocated to a particular conditioning treatment by random selection. The crop was mowed after the dew had evaporated. All mowing and conditioning operations commenced simultaneously. To do this it was necessary to have a separate mower for each plot except the flail-harvested plot. The crusher and crimper, drawn by separate tractors, followed immediately behind their respective mowers thus conditioning the crop as soon as it was cut. This procedure permitted direct comparison of the results of all methods including the combined mowing and conditioning effect of the flail harvester.

The moisture content (wet basis) of the forage was determined at the time of cutting. Three random samples of approximately ¾ lb each were taken from each treatment plot at two-hour intervals throughout the drying day in order to determine drying rates. Sampling began at about 7:00 a.m. and ended about 9:00 p.m. each drying day. The early morning and late evening samples yielded information regarding the effect on dew loss and pickup of the various conditioning methods. The samples were weighed as soon as they were removed from the field and reweighed after a minimum of 24 hr drying in a forced-air oven at 170 F.

In each field where drying rate tests had been made, subsequent tests were run to determine the magnitude of the field losses experienced with the various conditioning methods.

To determine pickup losses three plots 3 by 25 ft were randomly marked out within each of the treatment plots. These subplots were hand-raked and the yield recorded. Moisture samples were then taken for the purpose of determining the weight of loss corrected to a 15 percent moisture content. The 15 percent level was chosen, as opposed to oven-dry values, in order to provide a picture of the losses on an approximate storage-moisture level basis. Sample drying procedures were the same as those for curing-rate samples.

In the investigation of stubble-height losses, the same subplots were used as for pickup loss studies. Stubble loss data were collected on the same day as, and immediately following, pickup loss studies. Each subplot was mowed with a Jari mower to a common stubble height of approximately 2 in. It should be noted that these stubble losses provide only relative comparisons between the various machines since mowing to a common height will include some material not normally considered lost. This material was then collected, weighed, and sampled for moisture content. Dry yields were corrected to 15 percent moisture as in the pickup studies. Oven drying and weighing procedures were the same as those outlined previously.

Graphs and tables were prepared from individual tests and are indicated by the date of data collection.

Effect of Hay Conditioning on Drying Rates

The primary purpose of hay conditioning is to speed up the field curing of forage crops. Since considerable work has been done on the effects of crushers and crimpers, the emphasis on the work reported herein has been placed on the effect on curing rate of the flail-type forage harvester.

Fig. 1 shows the drying rate of an unconditioned, crimped, and crushed timothy-brome mixture. Although no

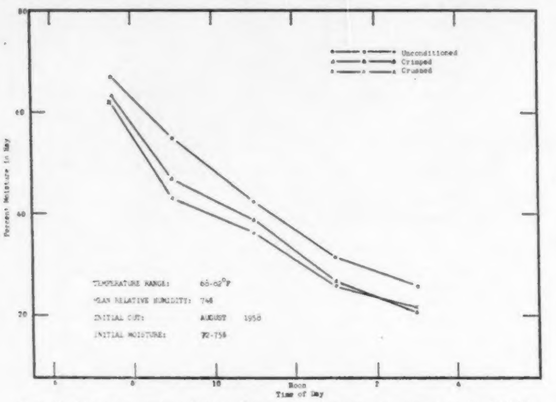

Fig. 1 Drying rate of timothy-brome mixtures, August 5, 1958

specific study of the effect of various crushing pressures was made, the machines were instrumented so as to provide information concerning the range of pressures experienced during the conditioning process. Both the crusher and crimper were initially adjusted in accordance with the manufacturer's instructions. The operational pressures ranged from a minimum of 24.4 lb per in. of roll length to a maximum of 29.9 lb per in. for the crimper, and from 31.9 lb per in. to 35 lb per in. for the crusher. In general, the test results indicate that crushing is somewhat more effective than crimping.

Fig. 2 compares the drying rates of an unconditioned,

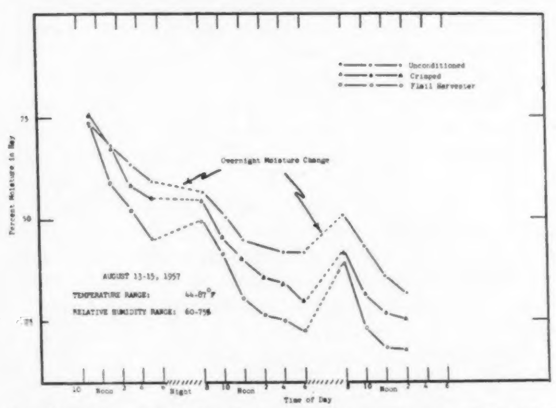

Fig. 2 Drying rate of timothy-brome mixture, August 13-15, 1957

crimped, and flail-cut timothy-brome mixture. It can be seen that the flail-cut material had the most rapid drying rate. It is also apparent that during the early morning hours the dew evaporates more rapidly from the flail-cut crop than from either the crimped or the unconditioned hay. One apparent disadvantage appears to be the greater overnight moisture pickup in the conditioned crop; but this is largely offset by virtue of the more rapid loss during the morning hours.

Fig. 3 shows a comparison between unconditioned and flail-cut alfalfa-clover mixtures. In general, legumes and legume mixtures appeared to dry more rapidly for any

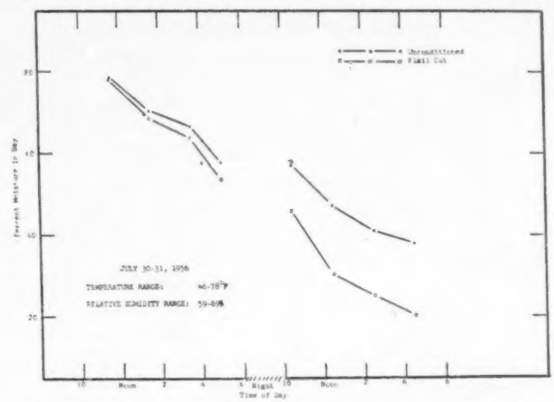

Fig. 3 Drying rate of Alfalfa-clover mixture, July 30-31, 1956

method of conditioning than did grass mixtures. It is apparent from Fig. 3 that the flail-cut material could be baled and stored at the end of the second day while the untreated crop would have to cure for at least a third day, or be placed on a hay drier at the end of the second day.

Since crushing is considered a somewhat more effective method of forage conditioning than crimping, the effects of crushing versus the flail harvester are compared in Fig. 4.

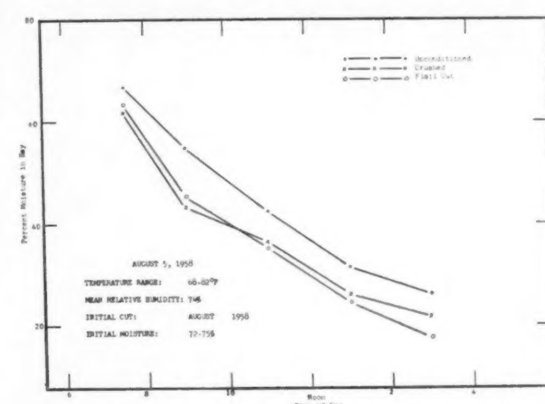

Fig. 4 Drying rate of timothy-brome mixture, August 5, 1958

During the early morning hours the rate of dew evaporation is about equal between the two treatments. Late in the forenoon the flail-cut material begins to show a drying advantage over the crimped material. By early afternoon the flail-cut material was ready for baling whereas the crushed crop still required several hours of additional curing to reach a similar point.

It should be noted that in Massachusetts, due to predominately cool summer weather, forage given a conditioning treatment generally requires about two days exposure for proper field curing. Unconditioned forage will require considerably longer exposure times in most cases. Table 1

TABLE 1. SUPPLEMENTAL DATA FOR TYPICAL TESTS REPRESENTED IN FIGS. 1-4

Date and crop	Temperature (deg F)	Relative humidity (percent)	Initial forage moisture (percent)	Time sampled	Percent moisture treatment after mowing			
					None	Crushed	Crimped	Flail-cut
July 30, 1956 Alfalfa-clover	46-79 for continuing period, July 30-31, 1956	59 to 69 for continuing period, July 30-31, 1956	78.5	11:30 a.m.	78.5			78.5
				1:30 p.m.	70.5			68.6
				3:30 p.m.	66.9			63.9
				5:00 p.m.	57.8			53.2
July 31, 1956 Alfalfa-clover				10:30 a.m.	57.7			46.2
				12:30 p.m.	47.6			30.2
				2:30 p.m.	41.3			25.1
				4:30 p.m.	38.4			20.5
Aug. 13, 1957 Timothy-brome	44 to 87 for continuing period, Aug. 13-15, 1957	60 to 75 for continuing period, Aug. 13-15, 1957	73.0	11:00 a.m.	73.0		75.0	73.7
			75.0	1:00 p.m.	68.4		68.0	58.7
				3:00 p.m.	63.2		57.9	53.2
				5:00 p.m.	59.0		54.9	44.5
Aug. 14, 1957 Timothy-brome				8:00 a.m.	56.8		54.9	49.8
				10:00 a.m.	51.1		45.1	41.3
				12:00 Noon	44.5		45.1	30.4
				2:00 p.m.	46.0		35.6	26.1
				4:00 p.m.	42.0		34.6	25.5
				5:00 p.m.	42.2		29.6	22.5
Aug. 15, 1957 Timothy-brome				8:00 a.m.	51.4		43.2	40.6
				10:00 a.m.	43.3		31.6	23.5
				12:00 Noon	35.9		26.7	18.5
				2:00 p.m.	31.7		25.8	17.9
Aug. 5, 1958 Timothy-brome	68 to 82	74 mean	75.0	7:30 a.m.	67.0	61.8	63.6	63.7
				9:00 a.m.	55.0	42.9	46.9	55.5
				11:00 a.m.	42.5	36.2	38.9	35.1
				1:00 p.m.	32.8	25.9	26.8	24.5
				3:00 p.m.	26.3	21.4	21.0	17.3

summarizes typical drying rate data for the different conditioning methods.

From the foregoing discussion it appears that the use of the flail-type harvester exhibits some advantage in speeding the field curing of forage over the more common methods of conditioning. Still another advantage of the flail harvester is the fact that in all cases the flail-type machine cut and conditioned equivalent areas in considerably less time than was possible with other conditioning methods. The harvester generally required only about two-thirds to three-fourths the operational time compared to the other methods.

One problem encountered in using the flail-harvester concerns the effects of rainfall on the cut material. Although rainfall did not appear to seriously affect the drying rate of other methods, the heavier rains did retard the rate of forage which had been flail-cut. Due to the shorter cut lengths and laceration characteristics inherent in the flail harvester, the crops cut in this manner exhibited tendencies toward matting and being driven into the stubble during heavy rains. In cases of relatively heavy rain, therefore, the curing of the flail-cut material could be considerably impaired.

Effect of Conditioning Methods on Field Losses

To further study the effectiveness of the flail-type harvester as a hay conditioning machine, tests were run to gain information concerning the field losses incurred through the use of conditioners. These losses were divided into "pick-up" and "stubble" losses. Pickup losses constitute material left on the ground by each conditioning method, after raking and baling operations. Stubble losses, on the other hand, are made up of the height of stubble remaining after the harvest has been completed.

TABLE 2. PICKUP LOSSES BY CONDITIONING METHOD

Treatment	CROP LOSSES Alfalfa Lb/acre @ 15% moisture	Alfalfa Percent of total yield	Timothy-Brome Lb/acre @ 15% moisture	Timothy-Brome Percent of total yield
Unconditioned	159	6.88	191	5.52
Crushed	254	10.99	141	4.07
Crimped	257	11.13	192	5.55
Flail-cut	327	14.16	365	10.55

The investigation of pickup losses, which involves stems and leaves remaining on the ground after completion of the harvest, showed losses approximately twice as great for flail-cut alfalfa as for the unconditioned crop (Table 2). The same relationship holds true in the timothy-brome mixture. These differences in both cases are likely attributable to the inherently short cut of the flail harvester, coupled with its comparatively more severe beating action. Because of these characteristics of the flail harvester, compared to other types of conditioners, subsequent pickup during raking and baling operations is rendered less effective. Also, the above results, and those following, apply only for the tests reported herein. Some variation in losses can be expected due to differences in crop condition, machine adjustment, etc.

Comparing flail-harvesting of alfalfa with other conditioning methods shows a pickup loss increase of less than 33 percent. The same comparison shows losses for the flail nearly double those of the other conditioning methods. This increase in losses in timothy-brome is probably due to the difference in growth characteristics between the plants. When green, the stems of alfalfa are relatively tough compared to timothy. Therefore, the action of the flails is more likely to merely kink and lacerate the alfalfa stems as they

pass through the machine. Being more brittle, timothy is more subject to the cutting action of the flails, as it is carried through the machine, thus being deposited in the swath in shorter lengths which are difficult to pick up. Also because timothy leaves are long and slender compared to alfalfa leaves, they are more likely to be exposed to multiple short cuts as they pass through the harvester.

Pickup losses in crushed and crimped alfalfa increased by about two-thirds over the unconditioned treatment while a similar comparison in the timothy-brome mixture showed no significant change. This phenomenon can be explained by the differences in leaf growth characteristics between timothy and alfalfa. The small, short-stemmed, bushy leaf growth of alfalfa is more subject to the stripping action of the rollers than is the long slender, blade-like growth of timothy. Thus, a greater proportion of the leaves are likely to be stripped from the alfalfa, only to fall to the ground and show up in the resultant increase in pickup losses.

In studying stubble losses it is important to note that these are relative comparisons of the various methods since mowing to a common height includes some material which is not normally considered as loss. For this reason, these values cannot be directly compared with the pickup losses. ... However, attention should be brought to the fact that the flail harvester leaves a stubble 2 to 4 in. longer than that for conventional reciprocating mowers. In practice, this difference may be offset by allowing an additional 2 to 4 in. of crop growth before using the flail harvester, providing such additional growth does not put the crop beyond its desirable stage of maturity.

Summary

Tests have shown that the use of hay-conditioning machinery during good drying weather definitely reduces curing time, with the smooth-roll crusher showing a slightly better advantage than the corrugated roll crimper.

The use of the flail-type forage harvester as a conditioning unit shows the advantage of a still faster curing rate coupled with a shorter time requirement for mowing and conditioning a given area. The problem of losses in subsequent handling, however, bears further investigation.

Following are some of the advantages to be gained from hay conditioning:

1 Speeds field curing. Conditioning can reduce drying time by about 30 percent.

2 Reduces weather damage. Shortening the time that hay remains in the field after cutting improves the chances of putting it up without damage.

3 Field losses due to shattering are reduced as curing time and the amount of turning and tedding are reduced.

4 Conserves color and feed value through shorter exposure and less shattering.

Performance of Forage-Conditioning Equipment

H. D. Bruhn
Member ASAE

As a prepared discussion of the preceding paper entitled "Hay Conditioning Methods Compared," the author reports on recent work of the effect of delayed crushing by various methods

THE history of the forage crusher is an interesting study. When crushing forage with rolls to increase the field-drying rate was first proposed in the early 1930's, this first research primarily raised the question: Can the drying rate of various forage crops really be increased? This question was answered in the affirmative by numerous experiment stations. For additional bibliography see reference (1)*. The questions which immediately followed were: How much is the drying rate increased? What other factors also affect the change in drying rate? And what if anything can be done to increase the performance of a forage crusher?

In previous research work we reported on the effect on crusher performance of such factors as roll pressure, roll speed relative to ground speed, roll size, and multiple-pass crushing. While we had compared various types of crushing equipment such as smooth rolls and different types of corrugated rolls, we hesitated to report these findings because the increase in drying rate caused by crushing with any type of equipment is affected by many other factors such as roll pressure, roll speed, atmospheric conditions, and maturity of the crop, to name but a few, and it is virtually impossible to adjust two unlike machines to operate with optimum performance even under one set of conditions. A change in such minor factors as temperature, wind velocity, ground moisture, or maturity of the crop may bring about considerable change in performance of one type of machine with respect to another. To invite in the various manufacturers of crushing equipment to put on a demonstration and then to attempt to evaluate the performance of a given crusher by drying rate obtained by a single performance is about as absurd as matching a white horse and a black horse in a single race and from the outcome evolve a hypothesis as to which color of horses can run the faster.

This paper reports our more recent work on the effect of delayed crushing and the relation of drying rate and clipping of leaves and small stems from the main stem as a result of crusher or conditioner action.

Delayed Crushing Tests

Considerable importance is occasionally placed on the elapsed time between cutting and crushing both on the basis of drying rate and trouble-free operation. Of the numerous tests conducted with a smooth steel-roll crusher and a flat bar-type corrugated-roll crusher, the results of two

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Acknowledgment: The author acknowledges the assistance of the following students who cooperated in conducting the tests and collecting the data for the study reported in this paper: James Doering, Arnold Zimmerman, Charles Jorgensen, Lambert Lasecki, Don Staab, and Milton Bennett.

*Numbers in parentheses refer to appended references.

series are shown in Figs. 1 and 2. While each of these are admittedly only the results of one day's operation, the tests

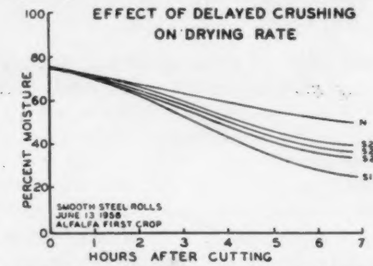

Fig. 1 A lapse of time between the cutting of forage and crushing has little effect on the drying rate, except that during the delay period the drying rate is comparable to that of uncrushed material. After crushing the drying then proceeds at the higher rate of comparable crushed material. Operating with the same roll speed but a slower ground speed usually gives an appreciable increase in drying rate

were duplicated numerous times with enough consistency to indicate these results to be representative.

The curves in Fig. 1 indicate the drying pattern from approximately 9:00 a.m. to 4:00 p.m. which in this climate comprises the major drying time of the day. The curve designated by the letter N represents a sample receiving no treatment other than mowing. The symbol S2D2 indicates a sample crushed with smooth steel rolls with the tractor pulling the crusher operating in second gear and a two-hour delay between cutting and crushing. Similarly, S2D1 indicates smooth steel rolls, the tractor operating in second gear, and a one-hour delay; and S2D0 the same except crushing immediately followed mowing. The maximum drying rate indicated by curve S1D0 was obtained by operating the tractor in first gear with no delay. For more details on the operation and adjustment of the machines for each test, the reader may refer to Table 1.

TABLE 1. SPECIFIC DETAILS REGARDING THE OPERATION OF THE VARIOUS CRUSHERS AND CONDITIONERS

Fig. 1 (June 13, 1956)
Smooth steel rolls
S1 Roll surface speed 2.2 times the ground speed of 2.7 mph.
S2 Roll surface speed 1.57 times the ground speed of 3.7 mph.
Zero roll clearance; initial pressure 30 lb per lineal inch.

Fig. 2 (June 14, 1956)
Corrugated steel bar-type rolls
C2 Roll tip speed 4.47 times ground speed of 3.1 mph.
Roll clearance maintained by spacers at roll ends.

Fig. 3 (June 30, 1958)
S1 and S2 same as above, smooth steel rolls

F4, 2.5 mph	F5, 3.1 mph	F6, 3.8 mph
F7, 4.7 mph	F8, 5.9 mph	F9, 7.3 mph

F4-9 Flail-type chopper; tip speed, 4750 fpm

Fig. 4 (July 21, 1958)
S1 and S2 same as above, smooth steel rolls

S3	Roll	surface	speed	1.2	times	ground	speed	of	5.0 mph
R1	"	"	"	6.3	"	"	"	"	2.6
R2	"	"	"	4.3	"	"	"	"	3.8
R3	"	"	"	3.2	"	"	"	"	5.1
R4	"	"	"	2.5	"	"	"	"	6.8

Fig. 5 (July 22, 1958)
S1 and S3 same as above, smooth steel rolls
R1, R3, R4 same as above

F1, 2.2 mph	F2, 3.1 mph	F3, 4.0 mph
F4, 7.0 mph		

The main objection to delaying the crushing time is that during the delay the forage drys at the slower rate of

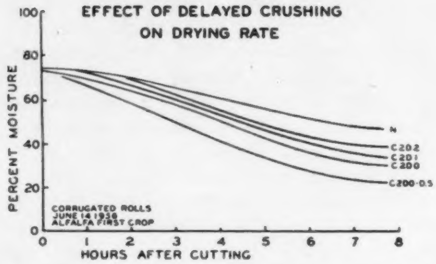

Fig. 2 A delay in the crushing operation has essentially the same effect, when bar-type corrugated rolls are used, as experienced with smooth steel rolls. Crushing immediately after cutting and then a repeated crushing after a one-half-hour delay produces an excellent drying rate

the uncrushed material, and the advantage of the higher drying rate of the crushed material is lost for the extent of the delay. After crushing takes place, drying proceeds essentially at the same rate as a sample of comparable moisture crushed immediately after cutting. More important under these conditions was that the relation of roll speed to ground speed on this particular machine was too low for optimum crushing in second gear.

The effect of delaying the crushing time when bar-type corrugated rolls are used is shown in Fig. 2. As before the letter N indicates no treatment, while C2D2 indicates corrugated rolls, the tractor in second gear, and a two-hour delay between cutting and crushing. Similarly, D1 and D0 indicate one-hour and no delay, respectively. Previous work had indicated that with this particular machine the tip speed of the corrugated crushing rolls was high enough that there was little difference between crushing with the tractor operating in first gear as compared with second gear. (High roll speed in corrugated-roll machines is necessary to prevent recirculation.) In this series of tests one sample, C2D0-D.5, was double-crushed, the first crushing taking place immediately after cutting and the second crushing after ½-hour delay.

The over-all pattern here was essentially the same as with smooth rolls. Delaying the crushing just meant a drying rate similar to uncrushed material during the delay and then a drying rate after crushing comparable to crushed material of the same moisture content. Double crushing with a delay between the first and second crushing produced a very high drying rate with a considerable jump at the time of the second crushing. Apparently the composite effect of picking up the once-crushed, slightly dried material, crushing it a second time, and tossing it in the air to drop in a new pattern brought about a sudden noticeable drop in moisture content. While this procedure is entirely within the farmer's province to perform, the advisability of recommending it is questionable because of the clipping that may take place, especially if there is an appreciable delay during good drying weather.

In the case of both the smooth-roll and the corrugated-roll machines, there was no indication of any increased tendency for the machines to clog or to wrap due to the delays in crushing. Possibly if a machine were on the point of incipient failure, when crushing immediately after cutting, a delay might cause trouble; however, in this case probably roll speed, pressure, ground clearance, or general machine construction would probably be the primary fault and the delay only a contributing cause.

Relation of Drying Rate to Clipping

In crushing forage to increase the drying rate, obviously there must be damage to the plant stems. The question arises as to the quantity of leaves and small stems that may be clipped from the main stems in this operation. While not all of the clipped leaves and stems will be lost in picking up the cured crop, it is quite logical to believe that the losses will be essentially in proportion to the clipping.

Figs. 3, 4, and 5 are a series of curves showing the relation of drying rate to clipping. The clipping is indicated as percent of separation which is determined by screening the sample through 2-inch-mesh poultry netting. The exact procedure will be described farther on in this paper.

Fig. 3 shows the relation of clipping to drying rate for

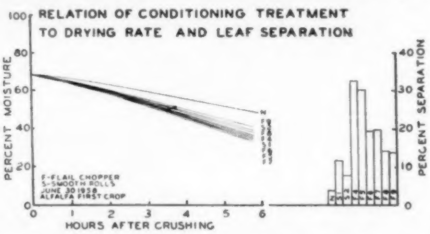

Fig. 3 For a given type of machine there is a definite correlation between clipping of short stems and leaves and the drying rate resulting from the conditioning operation. A flail-type chopper used as a conditioner caused considerably more clipping than a smooth steel-roll machine when conditioning a crop to produce a comparable drying rate

a smooth steel-roll crusher operated with the tractor in first gear (S1), and second gear (S2), and a flail-type chopper with a special cutter-head speed reducer, pulled by a 10-speed tractor in fourth to ninth speed, inclusive, designated as F4, F5, F6, F7, F8, and F9. As previously stated, the drying-rate curve designated by *N* indicates no crushing treatment, and the *N* bar in the percent separation group indicates percentage of short material present in the untreated sample. Thus the difference in the length of the *N* bar and any other bar is the clipping that can be charged to the crushing or conditioning treatment.

As would be expected, the clipping by the smooth rolls is an inverse relation to the rate of travel and the thickness of the mat of material passing between the rolls, and the increased drying rate is in direct relation to the clipping. This has been repeated many times and is very consistent. In the operation of a flail-type chopper converted to a hay conditioner according to manufacturer's recommendations, a similar relationship seems to hold in a general way. There is some inconsistency which is probably a result of experimental error, although there could be some other factors

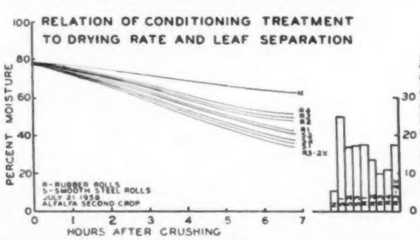

Fig. 4 The relation of clipping and drying rate resulting from crushing forage with fabric and rubber rolls follows the same pattern as that for other types of equipment, except that the actual amount of clipping is lower than that resulting from the use of most other equipment

such as limited compaction of the excessively chopped material. In general, however, the data indicate that, to approach an acceptable drying rate through the use of a flail-type chopper, the machine will need to be operated in such a way as to cause excessive clipping.

The results shown in Fig. 4 are of a similar study involving a smooth steel-roll machine and a machine equipped with two rolls made up of rubber and fiber and designated by R1, R2, R3, and R4, depending on the speed of the tractor pulling the crusher. With both machines clipping and drying rates were inversely related to travel speeds, and generally drying rate was essentially proportional to clipping. The test run R3-2x is the apparent exception. R3 indicates third-gear operation and the 2x indicates an immediate repeated crushing. The bar chart indicates essentially a 100 percent increase in clipping as compared to R3 less N (the original short material); however, there appears to be an exceptionally large increase in drying rate. This particular test was not repeated enough times to indicate if such results could be obtained consistently, or if this was an unusual situation. The general picture indicates that, while there may be some difference in the clipping of smooth steel and rubber rolls to produce a given drying rate, such difference is not pronounced. The tests indicate that the rubber-roll machine used in these tests should have been operated with either high roll pressure or a higher roll speed for a given power take-off speed. This is also true of the steel roll machine, for no farmer will want to operate his tractor in low gear just to make the crusher more effective when he has adequate power to pull the crusher in third or fourth speed.

The results of a series of tests involving the same smooth-roll and rubber-roll crushers used previously and a new experimental flail-type chopper pulled by a tractor with five speeds are shown in Fig. 5. There was appreciably less

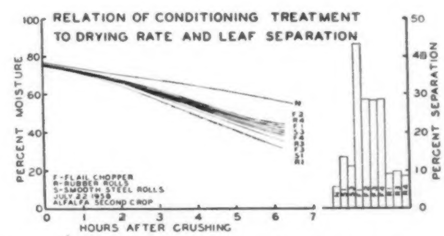

Fig. 5 A farmer operating these machines might be fairly well satisfied with the drying-rate increase resulting from the use of any of these machines at any reasonable ground speed; however, the potential losses due to clipping would make some of these conditioning treatments of questionable value

clipping by both the steel-roll and rubber-roll machine than in the previous day's operation, but the drying rates are in about the same pattern. While the crop was alfalfa in both tests, there probably was variation as a result of moving to a new location in the field the second day. The flail-type chopper, as in the tests shown in Fig. 3, again produced excessive clippings for a given drying rate. Neither the clipping nor the drying rate are exactly consistent with regard to the rate of travel. However, from a practical standpoint the question is only academic because with the generally excessive percentage of clipping and the mediocre drying rate of the material conditioned with a flail-type chopper, we would not recommend this type of machine as a forage conditioner until decided improvements can be shown.

. . . Forage-Conditioning Equipment

Procedures Used

Drying rates of forage given various conditioning treatments are obtained by the use of 3 x 4-ft shallow screen-bottom pan to catch a sample of the material as it is discharged from the machine. The sample is immediately weighed and corrected to a standard 6-lb sample. This is then placed on the ground where forage has just previously been removed. At one-hour intervals each sample is picked up and weighed and again set back in its original place. At the end of the day each sample is carefully collected in a large paper bag, labeled, and put on steam coils and dried to constant weight. The moisture content at each weighing is calculated from the final dry weight. Care is taken in placing the samples for field drying so that all receive the same sunshine, breeze, etc. (Fig. 6).

Fig. 6 *(Left)* **The samples for drying rate study are collected, dried, and weighed on light-weight fabricated pans. The sides of the pans are 2 x 2 in. folded sheet metal angles, and the bottoms are ¼ in. mesh hardware cloth**

All machinery is lined up in the field prior to starting so that there is a minimum of delay between treatments and samples. In normal operations the time lag between samples is three minutes or less, and this work is done at the early part of the day when drying is still limited by the low angle of the sun, high relative humidity, and low temperature.

The data collected for each sample is plotted on the basis of time after conditioning or cutting, depending on the test. By this procedure neither the first nor last sample seems to have an advantage. Duplicate check samples are frequently taken, one at the start and one at the finish, and the results are surprisingly consistent.

Percent of separation or clipping shown in Figs. 3, 4, and 5 is obtained by catching a duplicate sample immediately after the sample for drying rate study is collected. The sample for clipping study, however, is immediately sealed in a bag and taken to the laboratory to be separated. The fractions are then air-dried to constant weight, and the percent of separation is calculated on the air-dried weight basis.

Separation is accomplished by placing about one pound of the sample on a screen (Fig. 7) approximately 3 by 4 ft made of standard 2 in. poultry netting and bouncing the sample up ten times. This is repeated until the whole sample is separated. The air-dried fractions are shown in Fig. 8.

Fig. 7 The screen for separation studies is standard 2-in. mesh poultry netting. This was found to give essentially the same fractions as the time-consuming practice of picking out by hand all of the long stems. Further separation of the fine material through a similar one-inch screen did not seem to yield any information of value

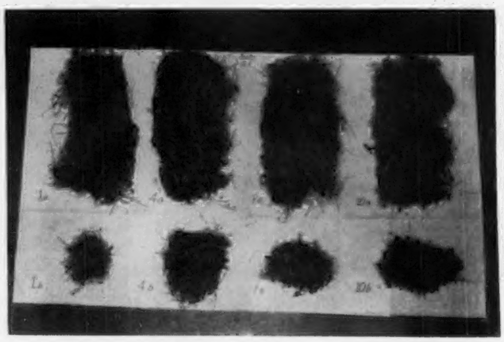

Fig. 8 These four samples were separated with the screen shown in Fig. 7. The "b" series are the short stems and leaves which went through the screen, while the "a" series is the long material, essentially full-length stems. The samples correspond to Fig. 4, July 21, 1958. No. 1 is N, No. 4 is S3, No. 7 is R3, and No. 10 is R3-2x

Conclusions

If equipment is in good order and properly adjusted, delaying the crushing of alfalfa beyond the cutting time has little effect other than the loss in the higher drying rate of crushed material during the delay. The actual magnitude of loss varies directly with the effectiveness of the crushing, the extent of the delay, and the adequacy of the drying conditions.

The use of a forage crusher to increase the field drying rate of a crop is generally desirable, but the operation causes some clipping of small stems and leaves, part of which are apt to be lost in the harvesting process.

With similar types of crushing or conditioning equipment the degree of increase in drying rate is essentially in direct relation to the degree of crushing and clipping.

Different types of conditioning equipment vary widely in the degree of clipping to produce a given increase in drying rate.

Reference

1 Bruhn, H. D. Status of hay crusher development. AGRICULTURAL ENGINEERING, 36: 165-170, 1955.

Discussion on Drying Rates and Field Losses in Hay Conditioning Methods

G. Russell Sutherland
Member ASAE

Drying rates and field losses are discussed in terms of swath and windrow drying

THE two preceding articles by Boyd and Bruhn deal with drying material in the swath. It should be pointed out, however, that some manufacturers advocate the cutting of material and discharging directly into a windrow, putting as many as three swaths into a windrow. In a way this is quite comparable to taking a load of wet laundry out of a washing machine and putting it into a clothes basket to dry. A recent report(1)* stated "Direct windrowing from a flail-type chopper is offered by several manufacturers. Experience with this process has varied from excellent to unsatisfactory. It appears that the process is satisfactory when humidity is low, weather risks at a minimum, and the surface and internal drainage of the soil is good." From this it can be assumed that drying from the windrow is satisfactory if there is no drying problem involved.

In discussion of drying rates reported by M. M. Boyd, his results agree with tests run by our company and with other published results. Essentially, when dried in the swath, hay conditioned with a flail-type chopper drys as fast as or slightly faster than any other method. Results of the loss studies presented no doubt are true and accurate for the tests he has run; however, our experience has shown that losses vary tremendously with crop conditions. Losses have run as low as 3 percent to as high as over 30 percent depending upon the given set of conditions.

It is known that customers today are using flail-type harvesters to mow and condition under two sets of conditions. The first is where losses are reasonable and the farmer feels the loss is not essentially different from that obtained with a conventional mower. Areas of upper New York state have been using flail-type harvesters to mow and condition Brome grass for at least five years. A second group is using the flail-type chopper where it is the only machine which will satisfactorily handle the crop. There are areas of Florida where Pangola, a grass which spreads by runners, is common. A conventional mower cannot cope with the tangled undergrowth and so the flail-type chopper is used. Many areas grow such tangled, jumbled, clover crops and even though the losses may appear high, the flail-type chopper is the only practical way to save the crop. For this reason further facts on stubble losses reported by Boyd in the timothy-brome mixture would be desirable, since normally the flail-type chopper will handle a lodged, tangled crop that a regular mower would not touch and under conditions other than ideal, the flail rotor would leave less stubble than a conventional mower. It seems that in a crop which is standing well a 2-in. higher stubble height is a function of the setting of the machine rather than a loss attributable to the machine.

In considering pickup losses, Boyd has indicated that the increased losses are due to the shorter cut and the inability of the side rake and baler to handle the shorter pieces. This is supported by an unsophisticated test we ran in very young, prebloom alfalfa. We ended up with 30 percent less weight of hay in 50 percent fewer number of bales. Losses resulted because length of cut was too short for raking and baling, although right for easy handling for silage, for which the machine was originally made. The length of cut of material coming off a flail rotor depends primarily on two things—the height of the plant and the characteristics of the plant itself. Unfortunately, a rotor takes about the same number of cuts at a stalk regardless of how tall it is and so, the taller the plant, the longer the cut. This is an oversimplification. Many factors such as knife design, hood design, use of baffles and knife speed affect length of cut but, in general, the taller the plant, the longer the cut. Also, the more fibrous the plant, the tougher it is to cut and the more apt it is to get past a knife merely crimped; and so it is apparent that something tall and wiry, like brome grass, results in a much longer cut than young, succulent alfalfa. Although alfalfa can be tougher than timothy, on the average, grasses give longer lengths of cut and lower losses than will alfalfa. It depends upon the actual conditions at the time of the test.

Boyd rightfully states that the problem of losses in subsequent handling should bear further investigation. Some manufacturers now provide two rotor speeds, using a slower speed for conditioning. This increases the length of cut and decreases the loss, but is not the whole answer since it reduces the knife tip velocity to a point where the rotor will not do a good job of cleaning the ground. This necessitates mowing separately and only conditioning with the flail rotor. The problem is to design a rotor with a tip velocity high enough to do a good mowing job which does not reduce the particle size to a point where losses are excessive. Considering the fact that flail-type choppers were not designed for mowing and conditioning, they do fairly well. The farm equipment industry can, and quite likely will, design a machine which will do a much better job.

Paper presented as a discussion of the article entitled "Hay Conditioning Methods Compared" by M. M. Boyd at the Annual Meeting of the American Society of Agricultural Engineers at Ithaca, N. Y., June 1959, on a program arranged by the Power and Machinery Division.

The author — G. RUSSELL SUTHERLAND — is product engineer, John Deere Ottumwa Works, Ottumwa, Iowa.

*Numbers in parentheses refer to appended references.

Reference

1 Barnes, K. K. Paper presented at 12th Annual Meeting of the American Society of Range Management, Tulsa, Okla., January 29, 1959.

Heat Stresses in Tractor Operation

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An approach to the problem of reducing the heat load on tractor operators in summer weather

THE heat stress resulting from driving a tractor in summer weather in Indiana is frequently more than a fit young man could be expected to stand safely for an 8-hr day. The frequency of this occurrence will be computed in the final phases of this study.

On the basis of one year's data with dry-bulb temperatures of 90 F or over, with relative humidity of 50 to 60 percent, and wind speed of 3 mph or less, a man driving a tractor with no shading would experience heat stress above the tolerable level for a fit young man. It is expected that older and impaired workers would have a lower limit of tolerable heat stress.

All of the sunshades studied by the authors reduced this stress to a tolerable level for a fit young man. The shade with the fan was more effective than those without fans. The aluminum-painted shade was more effective than the conventional shade.

The limitations of this study include the following: *(a)* the heat load from the tractor was not included, as no estimate of this has yet been obtained, and *(b)* the dynamic condition of the heat stress of a man on a moving vehicle has not yet been studied.

Introduction

It is necessary for the healthy human to maintain the body temperature within a relatively narrow range. At rest in a cool environment a man will use about 400 Btu an hour for maintaining body activity, the exact level depending on many factors including the age and the body weight or the surface area. Heat balance will be maintained partly by conduction and convection. At the same time, the man will lose heat by evaporation. The breath is saturated with water vapor, evaporating about 17 cubic centimeters per hour, and there is a loss of "insensible" perspiration of about 25 cubic centimeters per hour (11).* The heat balance can be represented by the following equation:

$$Q_{\text{Metabolic}} + Q_{\text{Radiation}} + Q_{\text{Convection}} + Q_{\text{Evaporation (lungs + insensible perspiration)}} = 0 \quad . \quad [1]$$

When this man is taken outside in the summer and put to work, the heat gain increases and so must the heat loss. A small amount of the heat gained may be stored in the body—about 250 Btu from a maximal rise of temperature of 2 F. The additional heat is mostly lost through sweating.

A typical heat balance under these circumstances might be as follows:

Weather data:	Black globe	110 F
	Dry bulb	92 F
	Wind	3 mph

$$Q_{\text{Metabolic}}\ (+800 \text{ Btu/hr}) + Q_{(\text{Radiation + Convection})}\ (+800 \text{ Btu/hr}) + Q_{\text{Evaporation}}\ (-1600 \text{ Btu/hr}) = 0$$

The level of heat gain is established by the metabolic load and the radiant load, while the change in heat loss depends mainly upon the capacity of the environment to evaporate the sweat and the capacity of the man to secrete it. The maximum sustained rate of sweat secretion for fit young men of Caucasian race for an 8-hour work period is between ¾ and 1 liter per hour, say, 2400 Btu per hr. Needless to say, clothing alters the heat balance on both the load and the loss side of the equation (8).

Indices of Heat Stress

The relationship of the heat load (the stress) and the resulting deviation of the individual from the resting rate of heat loss (the strain) can be predicted from several indices.

Effective temperature was one of the earliest of the proposed indices. The scale was originally developed for the comparison of environments but it has also been used as an index of heat stress (7). However, further research (5, 9) has shown the following defects in the scale:

1 It exaggerates the stress in dry, hot environments or does not allow for the effect of very high relative humidity in decreasing the sweat rate.

2 It makes no allowance for the increase in heat load from metabolic heat.

3 Its meaning, in terms of physiological stress, is unclear, although statistically it may account for about two-thirds of the variability in physiological response.

Paper presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1957, on a program arranged by the Power and Machinery Division. Authorized for publication as Journal Paper No. 1209 of the Purdue University Agricultural Experiment Station.

The authors — W. H. M. MORRIS, J. B. LILJEDAHL, and J. E. WIEBERS — are, respectively, associate professor of agricultural economics, associate professor of agricultural engineering, and assistant professor of biological sciences, Purdue University.

Authors' Note: The work reported in this paper forms a part of the Purdue Farm Cardiac Project, Purdue Agricultural Experiment Station Project 712, co-sponsored by Purdue University, Indiana Heart Foundation, American Heart Association, Indiana State Board of Health, and the National Institutes of Health.

*Numbers in parentheses refer to the appended references.

A radiant component has been added to the effective temperature scale; the combined scale is called *ETR*† by Yaglou. Yaglou and Minard have also presented the "wet-bulb-globe-temperature" scale (WBGT) as a heat stress index (12). The scale is correlated with the heat load except at high humidities when the wind speed greatly affects the capacity to evaporate sweat into the surrounding air.

The next important index of physiological stress from heat is the P4SR (predicted 4-hour sweat rate) (10). This Index is not effective unless the heat stress is sufficient to initiate sweating. Provision is made for the effect of clothing and for changes in metabolic rate. This index is widely accepted by European workers.

The Belding-Hatch HSI (heat stress index) (1) is based on a rational combination of the components of heat stress. The derivation is as follows:

Under comfort conditions equation [1] holds

$$Q_M + Q_R + Q_C + Q_{Ei} = 0$$

Since *Ei* is small compared with the heat loads under consideration, it is ignored.

If the environment is hot enough to initiate sweating, the heat load may be expressed in terms of the sweat required for thermal balance, *E req*.

$$Q_{E\ req} = Q_M + Q_R + Q_C \quad . \quad . \quad . \quad . \quad . \quad [2]$$

The response of the individual in terms of sweating, *E max*, can be predicted from the difference in vapor pressure between the skin and the air and the wind speed, up to a maximum of 2400 Btu or 1 liter of sweat per hour (the maximum tolerable rate of sweating over an eight-hour working day for a fit young man).

Since sweat rate is an adequate index of over-all heat strain, and sweating is proportional to the heat stress, then the ratio of heat strain to heat stress ($Q_{E\ req}/Q_{E\ max} \times 100$) provides a valid heat stress index, the Belding-Hatch HSI, for an environment. When *E max* would exceed 1 liter per hour, the maximum capacity of the individual to secrete sweat, 2400 Btu per hour must be substituted for *E max*.

The computations of the HSI are relatively simple when made with the nomographs provided by the authors (1).

Heat Load

It now becomes clear that changes in the heat gain represent changes in *E req;* in turn this represents changes in the HSI. We have, therefore, in the studies of the heat stress of tractor driving concentrated on the heat load, particularly the radiant temperature, as measured by the black globe, and the air speed. This provides an estimate of $Q_R + Q_C$ the radiant and convective load. The metabolic load for tractor driving (Q_M) is known from other studies which have been made at Purdue University, as well as from German data (4).

The physiological response of the individual to heat stress is primarily to increase the circulation of blood to the skin, with a corresponding increase in the work of the heart and the heart rate (6, 8). This supply of blood generally raises the skin temperature and provides water for sweating. The body temperature is also increased. If the environmental temperature is very high the blood may carry heat from the skin into the body. In this case, it has been reported (3) that men with impaired hearts may not suffer as much as normal men; the impaired heart will not circulate as great a volume of blood and so the cardiac may have a higher skin temperature but lower body temperature.

Under less extreme circumstances the cardiac will be at a disadvantage, because the impaired heart will not be as effective in circulating blood to the skin.

Reduction of Heat Stress

Relief from heat stress can be accomplished by *(a)* sunshading, *(b)* increased air speed, and *(c)* air conditioning, *i.e.,* reducing the relative humidity and reducing the air temperature.

The effect of sunshading can be predicted from the HSI. Every 1 F reduction in black globe temperature by shading over the entire body would reduce the radiant heat load by 50 Btu per hr.

Increasing the air speed has two effects: To a lesser extent it increases the heat load, and to a greater extent it increases the evaporative capacity of the atmosphere, *E max*. In fact, at high summer temperature, 90 to 95 F, and normal relative humidities, 60 percent and below, wind speeds above 6 mph tend only to increase the evaporative capacity over the rate of 2400 Btu per hour, the maximum tolerable for sustained periods of work. For this reason, high wind does not reduce heat stress under these conditions. At high relative humidities the vapor-pressure difference between the skin and the air is reduced so that a high wind velocity (up to, say, 20 mph) is very helpful in increasing evaporation. However, such a high wind velocity is not comfortable.

Air conditioning is generally accompanied by shading to reduce the radiant load and by forced cool ventilation with dehumidification to increase the vapor-pressure difference between the skin and the air. The result of lowering the heat load and increasing the capacity to evaporate sweat is to obtain a marked reduction in heat stress.

It is also possible to reduce the build-up of stress in the individual in a hot environment by a schedule of rest pauses. The rests have been shown to be more effective if taken in a cool environment (2). Rest pauses are essential when the heat stress is such that *E req* is greater than 2400 Btu per hour. An approximation of the rest allowance required is the time required out of the heat to reduce the average hourly sweat rate required to maintain balance to 1 liter (or less for an impaired worker).

Heat Stress Studies at Purdue

From the introduction at least two approaches are clear; meteorological studies can be made on the heat load and physiological studies can be made on the response of individuals to the load.

The heat stress studies made under the Purdue Farm Cardiac Project have been designed to study: *(a)* the physiological response of old and young workers to heat, and *(b)* the magnitude of heat load, obtained from weather data, and methods of reducing the heat load on the tractor driver. Only the latter are discussed in this paper.

The two-year studies at Purdue were designed *(a)* to

†ETR = 0.74 x 0.95 (black-globe, shade air temperatures) + shade air temperature. This has physiological meaning as the stress produced by the environment, but it does not include metabolic rate.

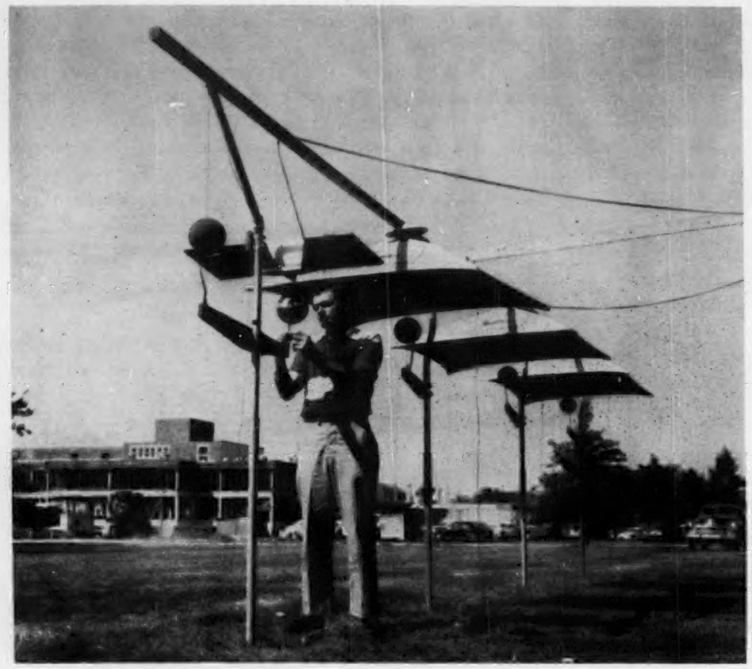

Fig. 1 Observation station for tractor shades

. . . Heat Stresses in Tractor Operation

obtain records of summer heat load in central Indiana, *(b)* to relate these records to the standard meterological data, *(c)* using this relationship to predict the frequency distribution of heat load from weather data on record, and *(d)* to establish the effect of different sunshades in reducing heat load.

Procedure Used in 1956

In the summer of 1956 one unshaded and three shaded stations (Fig. 1) were set up, each including a black globe and a dry-bulb thermocouple. A wet-and-dry-bulb thermometer was set up in a shaded location nearby. A chromium plated globe with a small heater inside was used as an anemometer; it performs in a similar way to a hot wire anemometer but has no directional properties.

All of the temperatures were measured from copper-constantan thermocouples, by a multipoint recording potentiometer. The potentiometer was set up to record for 15 min in every hour for 10 hr each day from midJuly, when the equipment was ready, until midSeptember.

In the first year three shade treatments were studied:

An untreated yellow tractor shade, 55 in. square

A similar shade painted with aluminum paint on the upper side

An untreated, yellow shade with a hole in the center and a 1/20-hp fan mounted beneath the hole blowing the air downwards, the hole being shaded by a cowl.

The record from the potentiometer was transferred to "mark-sense" cards. That is the cards were "marked" with a special electrographic pencil, and the marks were then "sensed" electrically and appropriate punches made in the cards. A set of potentiometer readings was marked on one card for each of the ten hours of observation for each day. The cards were prepunched and interpreted, that is, to indicate the year, month, day, and hour of observation. The mark-sense cards were punched and the temperature differentials obtained with the IBM 604 calculating punch.

A multiple regression was run to test the validity for a prediction equation for the globe temperature based upon the dry-bulb temperature and Δt wind (the difference between the chromed globe and dry-bulb temperature).

Results and Discussion

A tabulation has been prepared giving the following meteorological data for each hour from 8 a.m. to 5 p.m. for 56 consecutive days during July, August, and September, 1956:

Dry-bulb temperature
Wet-bulb temperature
Black-globe temperature
Wind velocity.

The maximum reading for each of these quantities for each hour of the day (Table 1) shows that high tempera-

TABLE 1. MAXIMAL VALUES FOR TEMPERATURES AND RELATIVE HUMIDITY FOR EACH HOUR OF OBSERVATION* IN OPEN AIR
(Lafayette, summer 1956)

Hour	Dry bulb deg F	Wet bulb deg F	Relative humidity, percent	Wind speed, ft per min†	Black Globe temperature, deg F
8 a.m.	80	74	76	470	94
9 a.m.	83	76	100	400	101
10 a.m.	87	77	95	470	105
11 a.m.	89	77	90	470	111
12 m.	90	78	86	470	112
1 p.m.	95	79	79	400	110
2 p.m.	94	79	76	400	112
3 p.m.	97	79	87	860	112
4 p.m.	97	79	84	670	110
5 p.m.	94	78	79	550	108

*In most cases the maximal values for any hour did *not* occur on the same day.
†Observations were made approximately 40 ft west of the agricultural engineering building. Obviously wind velocities greater than these would have been observed in open fields.

ture may be observed at any hour between 10 a.m. and 5 p.m. The maximum did not usually occur for more than one meteorological factor at one time. In the relatively cool summer there were several periods of high temperature, July 27 and August 4 and 5. The heat stress indices for metabolic loads of 8, 16, 24, and 32 Btu per min have been computed for the day on which the maximum heat stress would have been experienced (Table 2).

The effect of a difference of 11 deg in globe temperature on the heat stress index is considerable, as much as 40 lower on the Belding-Hatch scale or 500 Btu per hour lowering of the radiant load.

The effect of a sunshade under these static conditions will be somewhat different from a shade on a tractor moving in the field. It would be expected that the differences between the shades would be less with greater air movement.

TABLE 2. ESTIMATED MAXIMUM HEAT STRESS INDEX* FOR EACH HOUR OF OBSERVATION IN OPEN AIR
(Lafayette, summer 1956)

Hour	Date	Dry bulb, deg F	Wet bulb, deg F	Relative humidity, percent	Wind speed, ft per min	Black globe, deg F	HSI for various metabolic rates — Metabolic Rate† Btu per min: 8	16	24	32
8 a.m.	7/27	80	74	76	150	94	22	35	82	120
9 a.m.	7/27	83	76	73	240	98	35	65	92	120
10 a.m.	7/27	87	77	65	260	103	50	88	105	135
11 a.m.	7/27	87	77	62	167	111	82	118	150	180
12 m.	7/27	90	78	59	178	112	87	121	158	185
1 p.m.	7/27	91	79	59	240	107	39	47	98	127
2 p.m.	7/27	94	79	52	260	111	80	110	138	162
3 p.m.	7/27	96	79	48	285	112	80	107	135	160
4 p.m.	8/5	97	79	46	550	108	52	75	96	118
5 p.m.	8/4	94	78	50	550	105	44	64	85	105

*Belding-Hatch index. (An index of 100 is the maximum tolerable for an 8-hr day for a fit young man.)
†Examples to illustrate relation between metabolic rate and activity include:
6 Btu per min — Resting in sitting position.
16 Btu per min — Driving a tractor on light work.
24 Btu per min — Driving a tractor using front-mounted manure loader.
32 Btu per min — Shoveling at a slow pace, or carrying a 50-lb bag at 2½ mph on the level.

Farm work in the field has been shown to have energy requirements ranging from 8 to 24 Btu per hour. Loads as high as 32 Btu per hour are not likely to be met in the field but might be found in chore work inside and outside the buildings.

Effect of Sunshades

The effect of the sunshade is to reduce the globe temperature up to a maximum of 24 F. The reduction is greatest when the wind speed is low. The temperature differences under the different shades between 11 a.m. and 3 p.m. (Table 3) show that the shade with the fan was the most effective; the aluminum-painted shade was superior to the conventional yellow shade. Since the shades were mounted upright, the equalization of readings in the evenings is probably caused by failure to shade the globe as the sun declined.

TABLE 3. AVERAGE DIFFERENCE IN GLOBE TEMPERATURE SHADED AND UNSHADED FOR EACH HOUR OF OBSERVATION
(Lafayette, summer 1956)

Hour	Unshaded globe, deg F	Conventional shade, Δt deg F	Aluminum painted shade Δt deg F	Yellow shade with fan, Δt deg F
9 a.m.	70.6	7.8	8.8	10.7
10 a.m.	87.0	8.5	9.5	12.1
11 a.m.	90.5	8.7	9.9	12.1
12 m.	93.0	8.8	10.1	12.2
1 p.m.	94.0	7.2	8.7	11.0
2 p.m.	94.0	9.6	10.7	12.4
3 p.m.	93.3	9.2	10.2	11.9
4 p.m.	93.1	7.3	9.3	9.8
5 p.m.	90.5	6.2	6.6	6.6

Prediction of Black Globe Temperature

It would obviously be convenient to compute the heat stress index from the standard meteorological data. However, the radiation is not recorded by a standard weather station. For this reason a prediction equation for the black-globe temperature has been sought.

The regression equations (Table 4) show that a relatively high proportion of the variability in black-globe temperature can be explained by the dry-bulb temperature and Δt wind. The equations, while slightly different in form, generally differ little over the range of temperatures met at moderate wind speeds; at very high and very low wind speeds the relationship between the regression lines was less close (Fig. 2). The regression equations are significant with a high degree of probability (99.9 percent).

TABLE 4. REGRESSION OF BLACK GLOBE TEMPERATURE ON DRY-BULB TEMPERATURE AND ΔT WIND
(Lafayette, summer 1956)

Hour	Regression equation	Correlation coefficient r	F*
11 a.m.	B.G.T. $= 1.078$(D.B.) $+ 0.725\ (\Delta T_w) - 1.744$	0.84	64.9
12 m.	B.G.T. $= 1\ \ 16$(D.B.) $+ 0.471\ (\Delta T_w) - 0.332$	0.87	76.8
1 p.m.	B.G.T. $= 0.928$(D.B.) $+ 0.738\ (\Delta T_w) + 9.835$	0.88	91.5
2 p.m.	B.G.T. $= 1.033$(D.B.) $- 0.761\ (\Delta T_w) + 19.161$	0.53	10.4

*All equations are significant at 99.9 percent level; F for 2 and 51 or 53 deg of freedom=8

Wind speed $= 3750(\Delta T_w) - 1.073$ ft per min.

(Continued on page 683)

Flow Regimes in Surface Irrigation

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Development of Equations that Appear Valid for Characterizing Surface Irrigation Flow

THE design of surface irrigation systems involves flow phenomena which are complex and difficult to handle. The complexity of the total design problem has been widely recognized, but the complexity of the flow process has sometimes been underestimated. Simplified, empirical flow equations are widely used. Discrepancies between calculated and observed flow processes, such as rate of advance, have commonly been blamed on insufficient information relative to infiltration phenomena. In reviewing the situation it appears that much more work has been done on infiltration than has been done on the fluid mechanics of surface irrigation. We actually know, in many cases, more about the infiltration than we do about the fluid mechanics. Major errors can result from the use of flow equations which do not apply to the situation at hand and review of some of our present knowledge concerning the fluid mechanics of surface irrigation would seem in order.

The existence of two distinctly different types of flow in tubes and jets was noted by early investigators. Studies of this phenomenon were reported by Hagen in 1839 (7)*. In a paper published in 1883, Osbourne Reynolds discussed a rational parameter to distinguish the limit between the two types of flow which he called direct and sinuous (7). Reynolds rationalized that the development of eddies in tube flow would vary directly with velocity and tube diameter and with the ratio of fluid density to fluid viscosity. He then proceeded to verify experimentally that the "birth of eddies," or the development of turbulent flow, was dependent upon some definite value of the rationally developed parameter. This parameter, called "Reynolds number" is

$$N_R = VL\rho/\mu \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad [1]$$

where V is the average velocity, L is a length factor, ρ is the fluid density, and μ is the fluid viscosity. It should be noted that the length factor L must be a dimension relating to the generation of turbulence. Pipe diameter is the length factor used for flow in pipes, pore diameter or grain size is used for flow through porous media, horizontal distance from the leading edge is used for flow over flat plates, and hydraulic radius is used for flow in large open channels. There is a real question concerning a satisfactory dimension to be used in calculating the Reynolds number for the various conditions encountered in surface irrigation flow problems. For example, turbulence in flow through vegetation is undoubtedly more closely related to diameter, spacing and flexibility of plant stems and leaves than to depth of flow or a hydraulic radius which does not consider the presence of the vegetation.

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*Numbers in parentheses refer to the appended references.

When velocities of water movement are sufficiently low, agitation of the water particles is of a molecular nature only and the particles are held to motion in generally parallel paths by the action of viscosity. The stream lines, or stream surfaces, appear to divide the region of flow into layers, or laminae, which conform generally to the boundary configuration. Local disturbances in the flow pattern are damped out by the increased viscous stresses created by the disturbance. Shear stress between adjacent moving layers is determined by the fluid viscosity. This "layered" movement is called laminar flow. For true laminar flow the velocity distribution is parabolic and head loss is directly proportional to velocity. Boundary roughness has no effect on the flow properties in laminar flow other than to reduce the effective flow area.

As velocities increase, the kinetic energy of the water moving in disturbed flow paths becomes too great to permit damping of the disturbances by viscous forces and the disturbances spread throughout a major portion of the flow region. The water particles no longer move in orderly layers but move in a haphazard manner and complete mixing of the fluid occurs as flow takes place. This type of flow is classified as turbulent. Resistance to turbulent flow is not merely the result of viscous shearing stress between flow layers but is also created by momentum exchanges among fluid particles as they move from one layer to another in the mixing process. At higher Reynolds numbers the effect of viscosity on resistance to flow becomes insignificant. In turbulent flow the velocity varies essentially with the logarithm of the distance from the boundary, and head loss is proportional to the square of the velocity. Boundary roughness has a considerable and variable effect on the properties of turbulent flow since projections into the flow serve to increase the degree of turbulence.

There is no single value of Reynolds number dividing laminar from turbulent flow. Under the conditions of his experiment Reynolds found that laminar flow could exist at Reynolds numbers as high as 12,000 to 14,000 and other investigators have found that under special conditions laminar flow can occur at Reynolds numbers as high as 50,000. These upper limits of laminar flow, obtained under special experimental conditions, are of little practical concern to the irrigation engineer. He is interested in the lower limit of turbulent flow as defined by the Reynolds number below which laminar flow will always occur. This critical N_R has been established by many experiments to be approximately 2,100 for flow in pipes. Unfortunately for the irrigation engineer, considerable confusion and disagreement exists concerning the lower critical N_R for open channel flow.

Horten *et al* (1) conducted flow studies in a smooth wooden trough about 5.6 in. wide and 34.8 in. long. They worked with slopes ranging from about 0.25 to 0.07 percent and with flow depths ranging from about 0.005 to 0.015 ft. They questioned the use of N_R alone as a satisfactory criterion of flow regime in open channels and proposed a new

criterion utilizing a calculated critical velocity for a given flow depth and channel roughness and reported the critical N_R to be approximately 550 for the conditions of their tests. They did not propose that this was a fixed value and mentioned that other investigators had reported the critical N_R to be from 300 to 330. Their criterion, based on a calculated critical velocity, is an interesting approach but it has been questioned because they based their calculations on Manning's equation, which was not developed for shallow flows.

Parsons (3) utilized a channel with a concrete bed 2 ft wide and 8 ft long to study flow on slopes ranging from about 10 to 0.4 percent and with depths ranging from about 0.002 to 0.024 ft. He questioned the use of the hydraulic radius as the length factor in calculating the N_R for laminar sheet flow. His question was based on the fact that comparable equations for calculating velocity for laminar flow contained a one-half factor for flow in tubes and a one-third factor for sheet flow. These equations are

$$V = \tfrac{1}{3}\,\gamma\, R^2 S/\mu \text{ sheet laminar flow} \quad . \quad . \quad . \quad [2]$$

$$V = \tfrac{1}{2}\,\gamma\, R^2 S/\mu \text{ tube laminar flow} \quad . \quad . \quad . \quad [3]$$

where γ is the specific weight, R is the hydraulic radius of channel or tube, and S is the slope or hydraulic gradient. Accordingly he calculated the theoretical depth of laminar flow and assumed that flow was turbulent when the measured depth became greater than this calculated depth. For a smooth concrete floor he found the critical N_R to be from 500 to 700. Difficulties were encountered with this method when a slightly roughened concrete floor was used, with critical N_R becoming indicated as 35 for a 10 percent slope and 160 for a 1 percent slope. Questions relative to characterizing the roughness and accurately evaluating the flow were not resolved.

Owen (2) studied flow in a glass-walled flume with a polished brass floor 1.5 ft wide and 20 ft long. He did not present data on slopes and flow depths except to state that maximum depth was 0.3 ft. The existence of laminar or turbulent flow was determined by calculating N_R and friction-factor relationships from depth, slope and velocity measurements, and by the behavior of a stream of dye injected into the flow. This procedure indicated that the critical N_R was approximately 4,000. Other investigators questioned, among other things, the general applicability of Owen's results because velocity distribution had probably not stabilized in the measurement section and uniform flow probably did not exist, because flow in an open channel is actually three-dimensional as opposed to the assumed two-dimensional flow, because the critical N_R value is dependent upon channel shape, and because the laminar flow at a N_R of 4,000 could probably be classified as unstable and would have become turbulent if disturbances had been introduced into the flow.

It would appear that we are not at the moment sure of the critical N_R for shallow flow, even in smooth flumes. The critical N_R for shallow flow in extremely rough channels, such as those found in surface irrigation, is even more in doubt. We may assume that these latter critical N_R values will be quite low because of the continuous generation of eddies by the multitudinous projections into the flow and that most of the flow will be turbulent. We might also assume that the simplified empirical equations already developed for turbulent open-channel flow can be safely applied. This would be true if we could ignore the effect of boundary roughness and viscosity on turbulent flow.

A considerable amount of fundamental research has been done relative to the effect of boundary roughness on flow in pipes. Every student of fluid mechanics is familiar with the Darcy-Weisbach equation:

$$h_L = f\, L/D\; V^2/2g \quad . \quad . \quad . \quad . \quad . \quad . \quad [4]$$

where h_L represents the decrease in piezometric head over the distance L, D is pipe diameter, V is mean velocity, and f is the resistance coefficient or "friction factor". The work of Nikuradse on the variation of friction factors with N_R and boundary roughness is, as plotted in Fig. 1, also well known. Boundary roughness is characterized as "relative roughness," r/k, which is the pipe radius divided by the height of the boundary roughness projections. This shows that on the left side of the figure, for N_R less than 2,000, the friction factor is independent of relative roughness, which was previously stated to be a characteristic of laminar flow. On the right side of the figure it can be seen that the friction factor becomes a constant which is independent

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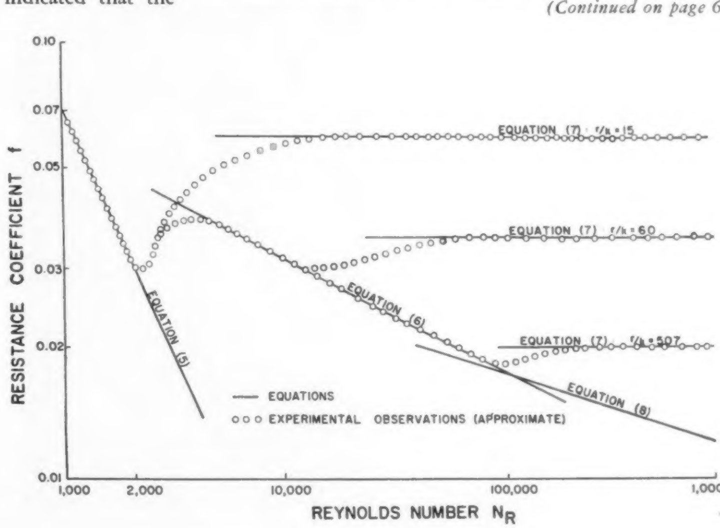

Fig. 1 Comparison of variation in resistance coefficient with Reynolds number (N_R) as determined by Nikuradse with pipes having three different values of r/k as predicted by equations [5], [6], [7], and [8]

Measurement of Soil-Tire Interface Pressures

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Diaphragm-Type Pressure Transducers Instrumented with Strain Gages in Soil-Compaction Studies

THE interest in soil compaction over the past few years has focused the research worker's attention on tractor and implement tires. While the causes of soil compaction are complex, weight and tires have been singled out as two of the major offenders. Farm implements and tractors are becoming larger and heavier and are making more trips over the soil.

The mechanical consolidation of tillable soils has reduced crop yields and in extreme cases forced removal of the land from agricultural production. As soil becomes consolidated, the mechanical strength of the soil is increased, the water-holding capacity is lowered and the water-infiltration capacity is decreased.

One approach to the soil compaction problem would be to redesign the present tractors and tires in order to maintain or increase drawbar pull while reducing soil compaction. Before this can be done, however, studies of present tires need to be made to determine the mechanics of traction and the magnitude and distribution of pressure at the soil-tire interface. (The interface is the area of contact between soil and tire.)

The purpose of the investigation reported in this paper was to measure the soil-tire interface pressures on the undertread, lug face, leading lug side and trailing lug side of a tractor tire at several drawbar loads and tire inflation pressures. The rear axle torque and slip of the rear wheel were also measured. The tests were conducted on a tire operating in a sand box.

Literature Review

Soehne (5)* studied the relation of tractor and implement tires to compaction and pressure distribution in the soil and presented engineering data on the subject. He found that the average pressure exerted by the lugs of a tractor tire in firm soil was four to five times as large as the average pressure for the entire contact area between the tire and the soil. He also found that the pressure was greater at the edges of the tire rather than the center due to the stiffness of the tire carcass. This last phenomenon was particularly noticeable at lower tire pressures.

M. G. Bekker (1) conducted a theoretical analysis concerning the pressure distribution under a tire, tire flotation and traction. He stated that tires with a flat tread may be considered better than those having a curved tread from the standpoint of more equal pressure distribution in the soil. Due to the complexity of pressure distribution and without an analysis of tire deflection in various types of soil, however, the relative merits of available tire types cannot be determined.

Recent work in the field of soil compaction has not been directly concerned with tires or traction. Cooper (2) and VandenBerg (8) developed and used a pressure cell to measure the pressures existing in the soil under tractor and implement traffic. The development of the cell provided a means for testing the theoretical stress-strain relationship in the soil proposed and tested by VandenBerg (7). Hovanesian (3) studied the empirical relationship between mean stress and bulk density in soils as affected by soil parameters.

APPARATUS AND INSTRUMENTATION

Tractor, Tire and Sandbox

The power unit used in these tests was a John Deere 1959 model 630 tractor. The static tractor weight with driver was 6760 lb and the weight on the right rear wheel (test tire) was 2400 lb.

The tests were conducted on a 13.6 x 38, 4-ply Goodyear tire. Pressure transducers were installed in the tire in holes drilled into the rubber. The holes were drilled with a $\frac{3}{4}$-in. wood bit (the centering screw filed to a short smooth point) operated by an electric drill.

Fig. 1 Tire with cells installed and terminal board

An analysis of the work conducted by Lask (4) indicated that at least five cells were necessary to form an accurate picture of the pressure distribution over a lug (one-half of the tire width). Thus ten holes were drilled across the tire at each of the following positions: undertread, lug face, leading lug side and trailing lug side (Fig. 1).

The tests were run in a box (8 x 16 x 1 ft) filled with mortar sand to a depth of 10 in. A concrete floor underlaid the sandbox. During the tests the moisture content of the sand varied from 7.8 to 12.7 percent (dry basis).

Drawbar Load

The drawbar load was varied between 40 and 1783 lb in approximately 400-lb increments by using a dead weight frame. The load remained constant during each run. Calibration and measurement of this load was accomplished with a load transducer instrumented with strain gages.

Torque and Slip

Torque of the right rear axle was measured by applying strain gages to the axle. Actual distance traveled D_a and theoretical distance traveled D_t (the distance the tractor would have traveled had there been no slip) were measured with microswitches on the loading frame and tractor, respectively. The microswitch mounted on the loading frame measured actual travel directly as the cable pulley rotated and the microswitch on the tractor counted the number of lugs traversed during the run. The distance the tractor traveled per lug on concrete with no drawbar load and at the appropriate tire inflation pressure was then multiplied by the number of lugs traversed to determine the theoretical distance traveled.

Pressure Transducers

The pressure transducers (strain cells) used in the tire were constructed in the following manner: A $\frac{5}{8}$-in. hole was drilled through the center of a $\frac{3}{4}$-in. cold rolled steel rod. An $\frac{11}{16}$-in. drill was used to enlarge the hole to a depth of $\frac{1}{16}$ in. A $\frac{3}{8}$-in. long cylinder was then cut from the rod and a $\frac{1}{8}$-in. hole was drilled through the side of the cylinder for the strain gage lead wire.

The diaphragms were made from stainless steel sheets 0.010, 0.020 and 0.025 in. in thickness. After rough cutting to a 1-in. diameter with a metal clipper, the diaphragms were soldered with stainless steel solder to the cylinders at the end with the $\frac{11}{16}$-in. inside diameter hole. The outside diameter of the diaphragm was trimmed in a lathe to the outside diameter of the cell. After the cell was constructed, a strain gage (type A-18) was glued to the backside of the diaphragm.

Proving tests were conducted on the cells mounted in the lug side by rolling the tire

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The authors: G. W. TRABBIC, K. V. LASK, and W. F. BUCHELE are, respectively, graduate assistant (MSU); lieutenant, U.S. Army, and associate professor of agricultural engineering, Michigan State University.

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*Numbers in parentheses refer to the appended references.

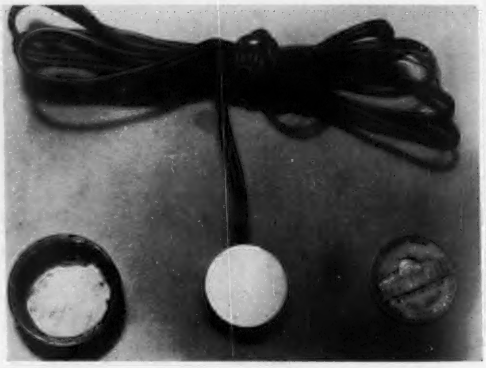

Fig. 2 Outside protective shell and diaphragm pressure transducer

Fig. 3 In-place calibration of pressure transducers

on a board. A load on the lug face caused a deflection of the oscillograph pen. The adverse effect of loads on the cell wall was eliminated by construction of an outer protective shell in the same manner as the strain cells. This shell was made of 1-in. material with a 13/16-in. hole. A slot was filed on the inside edge to provide room for the lead wire. A stainless steel diaphragm was soldered to one end to give the shell more strength. Tests showed that the shell eliminated the effects of side pressure on the lug face. Fig. 2 shows a strain cell and the outside protective shell.

With only one strain gage in each cell, the Wheatstone bridge of the amplifier was not temperature compensated. The effect of temperature change was reduced by covering the cells with five layers of cheesecloth and one layer of masking tape. Proving tests showed that the pen deflected less than ¼ psi when ice was placed against the insulated lug for 1½ sec.

Fig. 3 shows the in-place calibration apparatus. The cells were calibrated by holding the rubber diaphragm against the cell diaphragm and releasing the pressure. The pressure was raised to 60 psi on the lug face, leading lug side and trailing lug side, and 20 psi on the undertread. With this pressure setting, the attenuator and gain of the amplifier were set so the oscillograph pen deflected 30 lines. The pressure was released to check the zero-pressure setting. The pressure cycle was repeated three times. With the pressure off, the pen deflection was noted during resistance calibration for use during electrical recalibration.

PROCEDURE

The controlled variables in this investigation were drawbar load and tire inflation pressure. Because only sixteen channels of amplifying and recording equipment were available for the pressure transducers, four series of tests were required, to record the data from the 40 pressure cells and other strain gages mounted on tractors.

After the lead wires were attached to the terminal board mounted on the axle, the amplifiers were balanced and calibrated electrically.

Each series of tests was run by first adjusting the inflation pressure to 10 psi. With a 40-lb drawbar load, the tractor was driven forward approximately three-fourths of a wheel revolution in low gear and then backed up. This was repeated three times. One of the sets of weights was then hooked to the loading frame cable and the tractor driven forward and back three more times. This was done until the four weights were tested on the cable. The inflation pressure was increased to 14 and 18 psi in turn and the above test repeated.

The lead wires for this set of cells were removed from the terminals, another set attached and the procedure stated above was repeated. Before each test was run, the sand was thoroughly spaded and leveled. Actual and theoretical forward travel and torque were recorded during each run.

RESULTS

Trabbic (6) studied in detail the effects of tire-inflation pressure on the pressure distribution across the tire while operating in damp sand.

In each of the following figures concerning soil-tire interface pressure, the arrow points in the direction the tire slips with respect to the sand and the cells are numbered left to right (1-10). (The viewer faces opposite to the direction of travel of the tractor.)

Effect of Tire Inflation Pressure

For each of the figures mentioned in this section, the drawbar load was 1783 lb and the tire inflation pressures were 10, 14 and 18 psi.

Fig. 4 shows that as the tire inflation pressure was increased, the soil-tire interface pressure of the undertread increased at the center of the tire and decreased slightly at the edges. At the higher inflation pressures, the tire retained more of its unloaded shape. Also, at the higher inflation pressures, the percent slip was considerably higher, thus lugs packed the sand into the space between the lugs causing higher pres-

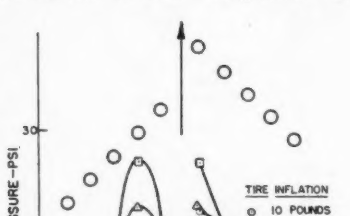

Fig. 4 Soil-tire interface pressure distribution across the undertread with a drawbar load of 1783 lb

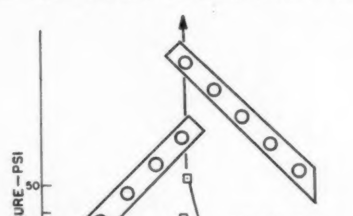

Fig. 5 Soil-tire interface pressure distribution across the lug face with a drawbar load of 1783 lb

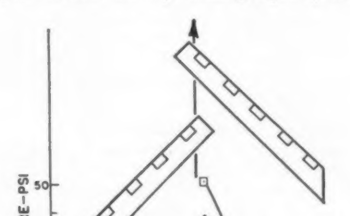

Fig. 6 Soil-tire interface pressure distribution across the leading lug side with a drawbar load of 1783 lb

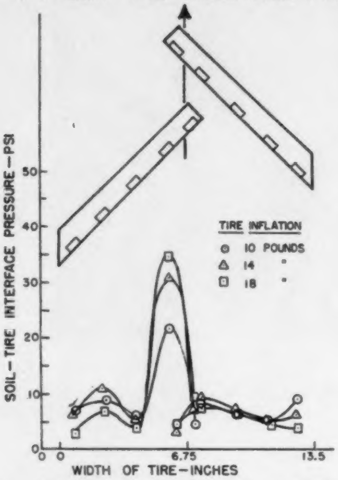

Fig. 7 Soil-tire interface pressure distribution across the trailing lug side with a drawbar load of 1783 lb

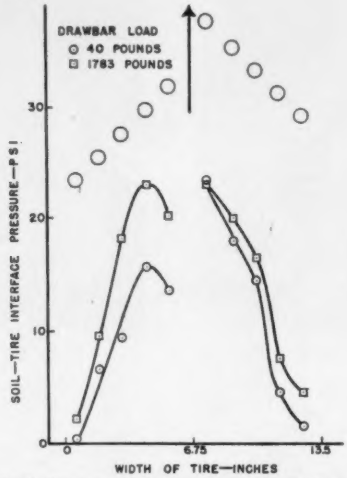

Fig. 8 Pressure distribution across the undertread with 14 psi tire inflation pressure and drawbar loads of 40 and 1783 lb

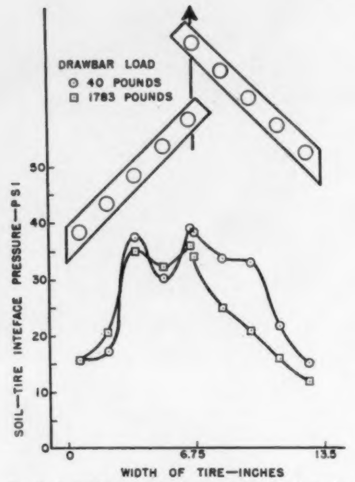

Fig. 9 Pressure distribution across the lug face with 14 psi tire inflation pressure and drawbar loads of 40 and 1783 lb

sure on the undertread at the center of the tire.

Fig. 5 shows the soil-tire interface pressure on the lug face at the various tire-inflation pressures. As the tire pressure was increased, the interface pressure at the center of the tire increased and at the edges, the interface pressure decreased. This interface pressure distribution was due to the tire retaining more of the unloaded shape at the higher inflation pressures.

Fig. 6 shows that the soil-tire interface pressure on the leading lug side increased at the center positions and decreased at the outside positions with increasing tire-inflation pressure. This was due to the retention of tire shape and increased slip with the higher inflation pressures.

Fig. 7 shows the effect of tire-inflation pressure on the trailing lug side. Distribution of interface pressure was similar to, but less than the other positions. There was a large increase of interface pressure with increasing tire-inflation pressure at cell number 4. The lug perpendicular to the instrumented lug apparently scraped sand into the cell as the tire slipped causing the pressure to increase. This condition probably occurred on the right lug, but was not measured because there were no cells in the comparable position.

Effect of Drawbar Load

For each of the following figures, the tire inflation pressure was 14 psi and the drawbar loads were 40 and 1783 lb.

Fig. 8 shows the effect of drawbar load on the soil-tire interface pressure distribution across the undertread. The curves show that with the high drawbar load, the pressure on the undertread was generally higher than with the low drawbar load. As the drawbar load increased, the dynamic weight transfer increased. Also, at the high drawbar load, the tire slipped considerably and as stated in the previous section, sand was packed into the space between the lugs.

Fig. 9 shows the effect of drawbar load on the soil-tire interface pressure distribution across the lug face. Generally the pressure on the lug face was higher with the 40-lb drawbar load than with the 1783-lb drawbar load. The lug established a sand prism (sand packed in the shape of a prism) as the lug pressed against the sand. Because of the low slip with the 40-lb drawbar load, the lug remained on the prism and the prism carried the weight of the lug, producing high soil-lug interface pressures. In the case of the high drawbar loads, the lug slipped off the prism and established another prism deeper in the sand. As the tire slipped sand was packed into the undertread area, the result was that the undertread carried a larger share of the vertical load of the tire.

An explanation for the high pressures at cells 3 and 8 is that as the lug entered the soil it flattened out and twisted. When the lug twisted, a pivot was established near the center of the lug. While the lug was twisting, both ends dug in while the pivot point developed a sand prism which supported the lug weight and created a high pressure point. This high pressure point was more noticeable at cell 3 than at cell 8. The reason for this could be that the tire was not exactly vertical and less weight was carried on this particular lug. As a result, the right lug (as viewed in the figure) flattened less and, consequently, twisted less than the other lug.

Fig. 10 shows the effect of drawbar load on the soil-tire interface pressure distribution on the leading lug side. The curves show that with the 1783-lb drawbar load, the interface pressure was higher than with the 40-lb drawbar load. This was due to the increased torque developed in the rear axle and the increased slip.

Fig. 11 shows that the pressure on the trailing lug side was generally greater with the 40-lb drawbar load than with the 1783-lb drawbar load. Because slip increased as the drawbar load increased, the trailing lug side tended to move away from the sand located in the space between the lugs.

The one noticeable exception to the above statement was at cell 4. At this point the pressure on the trailing lug side was higher with the 1783-lb drawbar load than with the 40-lb drawbar load. The reason for this has been stated in the previous section.

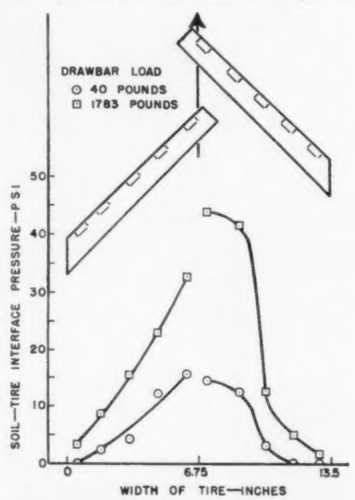

Fig. 10 Pressure distribution across the leading lug side with 14 psi tire inflation pressure and drawbar loads of 40 and 1783 lb

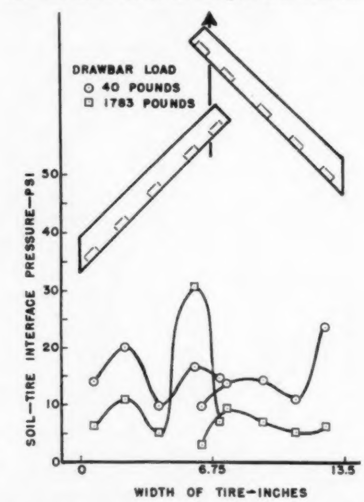

Fig. 11 Pressure distribution across the trailing lug side with 14 psi tire inflation pressure and drawbar loads of 40 and 1783 lb

A further explanation for the decrease of pressure at cell 3 is that the lug causing the increase at cell 4 took sand from in front of cell 3 thus lowering the pressure there.

Effect of Drawbar Load on Torque

Fig. 12 shows that rear axle torque increased linearly with drawbar load with 10 psi tire inflation pressure up to the maximum load used in these tests. The torque increased linearly at a tire pressure of 14 psi up to 1374-lb drawbar load and then increased at an increasing rate. The same was true at the 18 psi inflation pressure, except that the linearity extended only to the 928-lb drawbar load. The reason for the change in the slope of the rear axle torque versus drawbar load curve was due to the fact that the tire dug a rut at the higher percent slips (Figs. 13 and 14). The tire having dug a rut was virtually climbing an incline as it moved forward in the sand. This increased the torque required to pull a given drawbar load. As the tire slipped (dug in deeper) and developed a greater angle of contact, more lugs came in contact with the sand. Thus the traction required by the tire to pull the drawbar load was developed.

Effect of Drawbar Load and Torque on Slip

Fig. 13 shows that, with a tire inflation pressure of 10 psi, slip increased linearly with drawbar pull up to 928 lb and then increased at a slightly increasing rate. At the 14 psi inflation pressure, slip increased slightly up to the 928-lb drawbar load and then increased rapidly. With the inflation pressure at 18 psi, slip increased rapidly from the 40 to 446-lb drawbar load, remained constant to the 928-lb drawbar load and then increased at an increasing rate. The slip of the tire with an inflation pressure of 18 psi and 1783-lb drawbar load was nearly triple the slip at 10 psi and 1783-lb drawbar load.

A comparison of torque versus slip (Fig. 14) shows that slip increased slowly at all tire inflation pressures up to a torque of 1500 lb-ft. Above this torque value, slip at 10 psi tire inflation pressure increased at a slightly increasing rate. With 14 and 18 psi tire inflation pressures, the curves increased rapidly and nearly converged. The torque required to develop a drawbar pull of 1783 lb is shown by the top three points at the various inflation pressures. To pull the 1783-lb drawbar load in sand with a 10 psi tire inflation pressure, the tractor must develop 2,655 lb-ft of torque, 14 psi required 3240 lb-ft of torque and 18 psi required 3506 lb-ft of torque.

Dynamic Weight of Tractor

The vertical component of the pressures measured on the lug face and undertread were summed up and multiplied by the area to determine dynamic weight of the tractor. This result was found to be 5.4 percent higher than calculated with appropriate equations (6, 9).

The electronically measured dynamic weight was also used to calculate the point of application of the resultant soil force against the tire. This point of application was found to be 4.8 in. in front of the rear axle.

SUMMARY

Diaphragm-type pressure transducers instrumentated with strain gages were designed and built to measure soil-tire interface pressures. The interface pressure was measured on the undertread, lug face leading lug side and trailing lug side of a tire.

Drawbar load and tire-inflation pressures were the controlled variables in this investigation. The tests were run with drawbar loads of 40, 446, 928, 1374 and 1783 lb and tire-inflation pressures of 10, 14 and 18 psi. Three replications were run for each condition. The results were averaged for each cell position and plotted. The plotted data showed that high drawbar loads increased the interface pressure on the undertread and leading lug side and reduced the interface pressure on the lug face and trailing lug side. These plots also show that as tire inflation pressure was increased, the soil-tire interface pressure increased at the center of the tire and decreased at the edges.

Slip was measured during each run with two microswitches electrically connected to event marker pens on the oscillograph. One of the microswitches measured actual forward travel and the other measured theoretical travel. Percent slip was calculated from the data thus obtained and the results were plotted against drawbar load for each tire-inflation pressure.

The torque measured on the rear axle was plotted against drawbar load and percent slip for each tire-inflation pressure. The plot of torque versus drawbar load showed that torque increased linearly with drawbar load with a tire-inflation pressure of 10 psi. With tire-inflation pressures of 14 and 18 psi, the torque increased linearly up to 1374 and 928-lb drawbar loads, respectively, and then increased at an increasing rate. The plot of torque versus percent slip showed that percent slip increased slowly up to a torque of approximately 1500 lb-ft and then increased more rapidly, especially with the 14 and 18 psi tire pressures. This plot also showed that with a tire pressure of 10 psi, a torque of 2655 lb-ft in the right rear axle was required to develop a 1783-lb drawbar pull. With an inflation pressure of 18 psi, 3506 lb-ft were required to develop the same pull.

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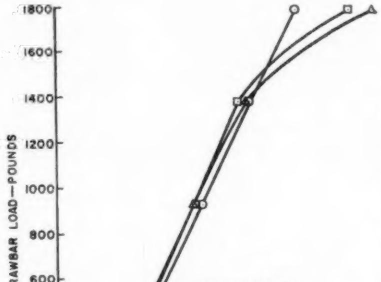

Fig. 12 The effect of drawbar load on rear axle torque with tire inflation pressures of 10, 14 and 18 psi

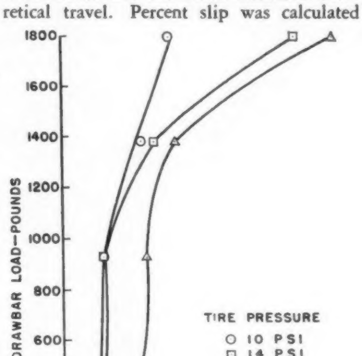

Fig. 13 The effect of drawbar load on percent slip with tire inflation pressures of 10, 14 and 18 psi

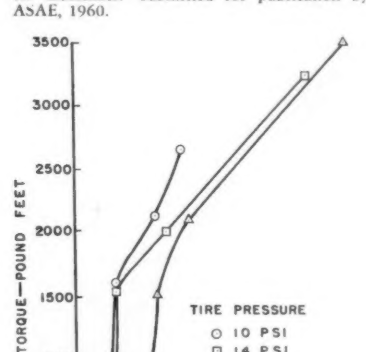

Fig. 14 The relationship of torque and percent slip with tire inflation pressures of 10, 14 and 18 psi pulling a 1780-lb drawbar load

. . . Flow Regimes in Surface Irrigation

(Continued from page 677)

of N_R, and therefore of viscous effects, and is a function of relative roughness only. For each graphed line there is a region from $N_R=2{,}000$ to some higher value of N_R where the friction factor is not independent of N_R. Although the flow in this region is classified as turbulent, the resistance coefficient is a function of both viscous forces and relative roughness. The laminar flow region is described by the equation

$$f={}^{64}/N_R \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [5]$$

which corresponds to the Hagen-Poiseuille equation. Flow which is turbulent but has a significant boundary layer of laminar flow is described by the empirical relationship of Blasius

$$f=0.316/N_R{}^{1/4} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [6]$$

It will be noted that the least rough pipes, indicated by the highest values of r/k, follow the line plotted for this equation until relatively high values of N_R are reached and the laminar boundary layer becomes thinner and less effective. As the curves flatten out and become independent of N_R the Karman-Prandtl resistance equation;

$$1/\sqrt{f}= 2 \log_{10} r/k+1.74 \quad . \quad . \quad . \quad . \quad [7]$$

applies. It should be noted that three distinctly different equations are required to characterize the flow under these three conditions. It should also be noted that none of these three equations apply to the transitions among the three flow conditions. A fourth equation

$$1/\sqrt{f}=2 \log_{10} N_R \sqrt{f}-0.8 \quad . \quad . \quad . \quad . \quad [8]$$

is required to describe turbulent flow in smooth pipes.

Flow relationships developed for pipe flow do not apply directly to open-channel flow. General relationships are similar, however, and some important observations may be made which do apply directly to open-channel flow. Perhaps the most important of these is the fact that resistance coefficients for turbulent flow at lower and intermediate values of N_R are dependent upon both viscosity and relative roughness. Resistance coefficients for highly turbulent flows are not greatly influenced by viscosity but are still a function of relative roughness rather than absolute roughness.

Flow in large open channels commonly occurs at high N_R where the effects of viscosity may be safely ignored. Under these conditions, empirical equations which do not consider viscosity may be satisfactory. Flow in surface irrigation commonly occurs at low N_R and a valid equation must, under these conditions, include a viscosity factor. Relative roughness does not vary greatly in a given large channel section where absolute roughness is small in relation to the cross-sectional area of flow. Relative roughness is of extreme importance in shallow flow or furrow flow where the absolute roughness, as depicted by Manning's "n", may remain reasonably constant but the relative roughness is varied greatly by the changes in flow depth which occur during the irrigation process. It should be pointed out that, as commonly used, empirical flow equations, such as Manning's, do not consider viscosity and do not adequately consider relative roughness. Although, for reasons just stated, these factors may be discounted in large open-channel flow, they cannot be ignored for the flow occurring in surface irrigation. Many difficulties encountered in attempts to characterize Manning's n for various conditions of irrigation flow have quite probably resulted from the fact that Manning's equation did not apply to the flow conditions under study.

A number of investigators working with open-channel flow have proposed the use of the Chezy formula

$$Q=CA \sqrt{RS} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [9]$$

where Q is the discharge, C is the resistance coefficient, A is the cross-section area, R is the hydraulic radius, and S is the channel slope. Various equations to characterize C have also been proposed. Powell (4) suggested that C for flow in channels could be characterized by

$$C=-42 \log_{10} (C/N_R+k/R) \quad . \quad . \quad . \quad [10]$$

The C/N_R term becomes negligible for values of N_R more than ten times the critical N_R, and the k/R term becomes negligible for values of N_R less than one-tenth the critical N_R. Several investigators have proposed for rough channels a relationship of the form

$$C=a+b \log_{10} (R/k) \quad . \quad . \quad . \quad . \quad . \quad [11]$$

The constants a and b must be determined experimentally. This equation is of the same form as the Karman-Prandtl equation for rough pipes. Values of these constants have been determined for various types of artificial roughness, with sufficiently close agreement among the different investigators to make equations of this type appear quite promising (5). Powell suggests that in channels the transition from smooth to rough flow may be so abrupt that characterization of the transition zone may not be a problem. This proposal would be most convenient if proven true.

Equations of the type just given are admittedly more difficult to calculate directly than are the simpler equations now commonly in use. Rouse (6), Powell (5), and other workers have stated, however, that tables and graphs can be developed to simplify the use of the more complex but valid flow equations. The use of strictly empirical equations cannot be justified merely on the basis of their simplicity. In considering the difficulty of calculations, there is a real question concerning the ease of using supposedly simple flow equations when supposedly constant retardance coefficients are found to be not constant.

The hydraulics of flow in surface irrigation represents an essentially new field in which little directly applicable basic research has been done. Research in this field has undoubtedly been retarded by the confounding and confusing effects of infiltration which have often been blamed for difficulties in predicting flow processes. Some of these difficulties have resulted, however, from the use of simplified empirical equations which do not accurately characterize the flow. Despite the inadequacies of the simplified empirical equations, the information needed for the use of rational flow equations has not yet been adequately developed. The need for this information is great and immediate and warrants the attention of every irrigation engineer.

Summary

The complexities of flow processes in surface irrigation have not been widely recognized and simplified empirical

flow equations are commonly utilized in surface-irrigation design. Discrepancies between calculated and observed flow processes have usually been blamed on insufficient information concerning infiltration phenomena. It appears, however, that in many cases the information relative to infiltration is considerably better than that concerning the mechanics of the surface flow involved. Use of flow equations which do not apply to the situation at hand can result in major errors. Review of existing information applying to the fluid mechanics of surface irrigation shows that *(a)* hydraulic radius is not a satisfactory dimension for calculating Reynolds number in surface irrigation flow, *(b)* critical Reynolds number for shallow flow has not been satisfactorily determined, *(c)* equations for turbulent flow at low Reynolds numbers must contain a viscosity factor, and *(d)* equations for surface irrigation flow should consider relative roughness rather than absolute roughness. Flow equations have been developed which appear valid for characterizing surface irrigation flow. Considerably more attention should be given to these equations, and the constants, tables and graphs required for their use should be developed.

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. . . Heat Stresses in Tractor Operation

(Continued from page 675)

A simple regression has also been computed showing the relationship between the globe and dry-bulb temperatures (Table 5 and Fig. 2). For average wind speeds (Δt = 10—16 deg), this simple relationship will coincide with the multiple regression.

TABLE 5. REGRESSION OF BLACK GLOBE TEMPERATURE ON DRY-BULB TEMPERATURE
(Lafayette, summer 1956)

Hour	Regression equation
11 a.m.	G.T. = 1.104(D.B.) + 6.194
12 m.	G.T. = 1.104(D.B.) + 6.807
1 p.m.	G.T. = 0.899(D.B.) + 21.792
2 p.m.	G.T. = 0.982(D.B.) + 13.937

The regression will be tested with data from the second year of observation, which are now available.

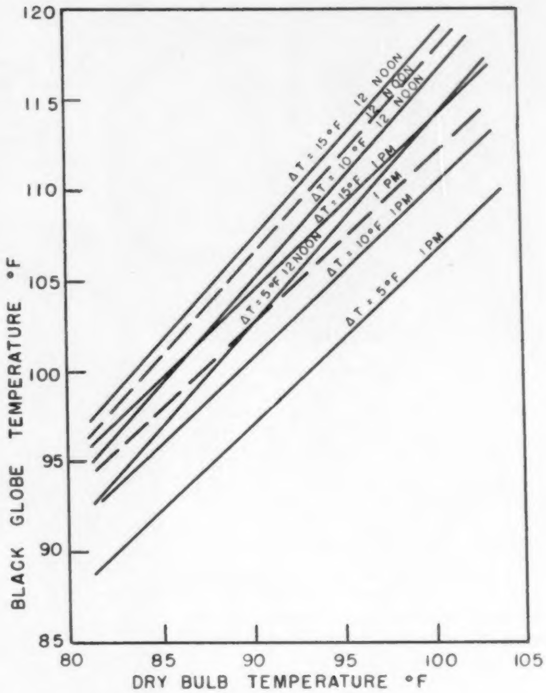

Fig. 2 Regression of black-globe temperature on dry-bulb temperature and Δt wind (solid lines) and on dry-bulb temperature alone (broken lines) (Lafayette, summer 1956)

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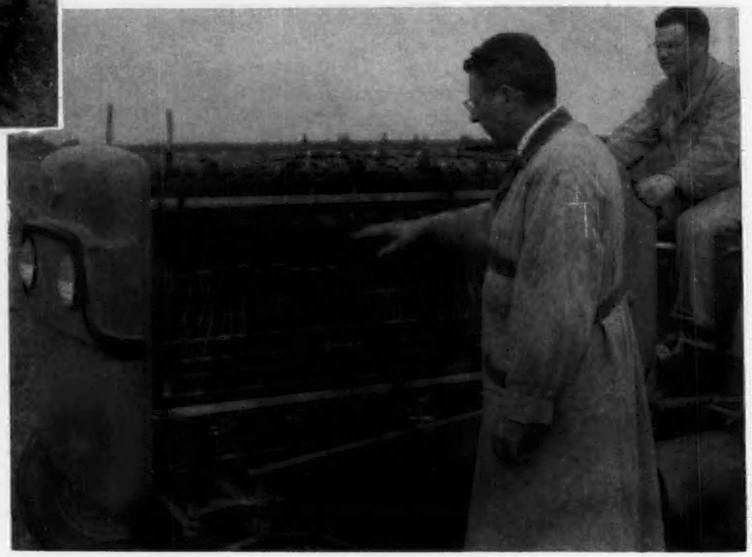
Tractor Powered by 1008 Fuel Cells



Electricity produced by fuel cells powers this experimental tractor. Chemical reactions between a mixture of fuel gases and oxygen — largely propane — and an electrolyte within the cells produce 15 kw of electricity. The direct current goes through bus bars (the bright horizontal bars shown at right) to a compact controller which regulates the speed and direction of the tractor by controlling the amount of current reaching the 20-hp motor.

A NEW kind of tractor, which actually has no engine, has been developed by Allis-Chalmers Mfg. Co. The new tractor, although considered to be in its experimental stage, reportedly develops at least 3,000 lb of drawbar pull. It derives its power from electricity furnished by 1,008 fuel cells. These are joined in 112 units of nine cells each. The 112 units are arranged in four banks and electricity can be taken from any combinations of the banks.

In operation, the fuel cell instantaneously converts chemical energy to electrical energy as direct current. The chemical energy is in a mixture of fuel gases — largely propane. In the fuel cell, the mixture of fuel gases is fed to the anode electrode and adsorbed by the catalyst on the electrode. It is activated there and reacts in the electrolyte. This reaction releases a stream of electrons (direct current) to the external circuit.

Meantime, oxygen is adsorbed at the cathode electrode and it reacts with an electron from the external circuit and with the electrolyte, thus reforming the ion which was used up at the anode electrode. The overall reaction is the consumption of the fuel gases to yield water and carbon dioxide and produce a flow of electrons (direct current) through the external circuit.

The compact controller, measuring 8 by 11 by 21 in., regulates the electricity supplied to a standard 20-hp d-c motor. The controller permits the tractor driver to regulate speed or reverse the tractor's direction by moving two levers. Using the speed control, the operator places the four banks of cells in series or parallel, varying the amount of current going to the motor. To reverse the tractor, the driver moves the second lever, changing the polarity of the current flow to the motor.

The tractor weighs 5,270 lb and carries its own fuel tanks. In fuel tests, it reportedly pulled a two-bottom plow for 17 minutes with two lb of propane, about equal to ⅓ gal of gasoline.

The compact control unit mounts alongside the seat. It connects the four banks of fuel cells in series or in parallel to vary the current going into the motor.

Specifications:

Number of fuel cells: 1,008
Fuel cell dimensions: ¼ in. thick, 12 in. square
Fuel cell voltage: approximately one volt open circuit
Total electrical output: 15 kw
Fuel gas used: a mixture of gases, largely propane
Type of motor: standard 20-hp d-c
Tractive power: 3,000 lb at drawbar on dynamometer
Tractor weight: 5,270 lb.

. . . Systems Engineering

(Continued from page 663)

encies too numerous to mention here except in terms of categories. There are, for example, the immediate and fixed mechanical interdependencies, such as are found in the tractor-tillage unit. There are interdependencies in product form and quality; for example, whether the harvesting method produces loose, chopped, baled, or pelletized materials determines the opportunities and limitations in subsequent materials handling and storage and usefulness in feeding. There are interdependencies in equipment use as given equipment units—for example, the tractor—are employed in successive stages of the process. Another form of interdependence is capital investment—in the form of machines or structures—of one time period, which may greatly influence technical modifications in a later time period. Finally, the process is complex. All of the foregoing are "system" attributes.

Many other systems of single-crop production could be described, and the concept is easily extended to multiple-crop production on a single farm. Even wider extension beyond the farm gate may be suggested. There is, for example, a growing number of farm-supply services that affect on-farm operations and equipment. These include bulk feed delivery, custom services for the application of fertilizers and insecticides and for pruning and cultural operations, and so on. In the sale and distribution of farm products, there are similar developments. Examples are the use of tank trucks in the farm-to-market transportation of milk and the use of pallet-bins in coordinated grower-processor harvesting of fruits and vegetables, their transportation, and their handling and storage at the processing plant. A less obvious but important influence is the growth of contract and specification buying by food processors and distributors whereby type and quality of product as well as on-farm production and cultural practices are specified. Finally, some observers foresee further growth of integrated production-processing-distribution operations under a single management such as are found in some portions of the canning industry and, more recently, in poultry production and marketing.

In agricultural production and marketing there is evident need to coordinate the many individual operations and stages. With numerous alternative techniques for performing particular tasks in such systems, there is further need—under commonly accepted criteria—to select from all such alternatives the particular operation and stage techniques that, as parts of a coordinated, unified system, will most satisfactorily meet prescribed goals. One way to accomplish this selection and coordination is to let the individual components fit themselves into the over-all scheme, and to a large extent this does happen. In contrast, the systems concept involves a deliberate search for knowledge of the system—its parts and their interrelationships—and a methodical pursuit of the optimum organization.

In a planned approach to systems studies, two levels of activity may be defined: *(a) systems analysis,* involving the definition, description, and study of processes (their components and interrelationships), and the discovery of optimum relationships, and *(b) systems design and development,* involving research and development aimed at methods improvement at the level of individual operations and stages and the translation of the results of systems analysis into plans of action. In agriculture these two phases involve the application of technology from many different fields. To the extent that they deal with materials, structures, machines, energy, and their control they become a special interest of engineering.

Systems Analysis

A point of beginning in any approach to systems analysis is, of course, the selection of performance goals and criteria. These will vary with the type of problem under study. Agricultural systems analysis, for example, might be aimed at minimizing soil loss, maximizing output, minimizing the costs of given outputs, or—if directed toward a solution for an individual firm—maximizing profit§. Such goals might be considered singly, or there could be a primary goal subject to specified limitations in regard to other subgoals. One could have, for example, the single goal of maximum immediate output from given resources; or this goal might be conditioned by certain restraints as to acceptable levels of soil loss. In any event, the systems visualized, the criteria for judging them, and the optimum solution very likely will be different depending on the goals sought. Selection of goals and criteria is, therefore, a vital and first step.

This introduces a second aspect. The approach must emphasize the fact of numerous production stages with—in each stage—the possibility of two or more techniques for performing given tasks. In agricultural systems studies, alternative techniques must be broadly defined to include different work methods and equipment, different soil and fertilizer treatments, alternative plant and animal strains, and so on. The central problem of systems studies then is the identification of the techniques in each stage that will, in combination with similarly selected techniques in other stages, constitute an optimum organization.

The complexity of this problem grows as the number of stages and alternative techniques increases. For example, assuming no restraints as to possible combinations of alternative techniques, a five-stage process with two alternatives per stage offers the possibility of $(2)^5$ or 32 different combinations. With ten stages and two alternatives per stage, the possible combinations are $(2)^{10}$ or 1,024; and, if there were four alternatives per stage in this process, the possible number of different combinations would total 37,179.

With exceedingly simple problems, alternative forms of process organization could be compared on the basis of controlled experiment. Only a little growth in complexity, however, would make necessary the comparison of many different alternative combinations. This might require in most situations hundreds, possibly thousands, of replications—totals that in comparisons of alternative systems through controlled experiment might generally be prohibitive. Moreover, the systems of interest generally involve operating procedures of entire farms and may extend beyond farm limits to include activities in farm-services supply or in processing and marketing. Controlled physical experiment in such a sphere, even on a very limited basis, is likely to be difficult, costly, and unsatisfactory.

A useful alternative to experimental comparison of entire systems is the representation and comparison of alternative systems through synthesis or "model" building. Physical experiment in this procedure is applied at the level of individual operations and stages, i.e., the component parts of the process. From the results of such experiments there is obtained in regard to each operation detailed information as to equipment and method of performance, as to the type, timing, and rate of use of the various inputs, and as to quantity, type, and quality of output. From such data estimates can be made of the type of inputs, their rate of use, and the costs of inputs in a particular operation or stage required to yield a particular *system* output. This kind of determination with respect to each operation and stage and with respect to alternative techniques in each stage provides a set of "building blocks," which can be "assembled" in different combinations, each representing an alternative system organization.

If the framework of evaluation is cost minimization, comparison of estimated total costs of given outputs from all alternative technical combinations then provides a basis for selecting the optimum system organization‖. This procedure rests on an easily recognized function of engineering—the *use of basic physical data to simulate through design a complex physical entity.*

While a research technique such as the above is certain to be less costly than an approach requiring physical experiment with complete systems, it too is likely—in the precise form described—to be a slow and expensive procedure. For an analyst attempting to apply it to complex processes there are appropriate simplifications and short cuts.

One such simplification is to "factor out" variables not expected to have a significant impact on the end result. Such variables may be ignored in the analysis or assigned fixed values#. This possibility may be frankly recognized without degrading the quality or validity of the research technique proposed. It admits the impossibility of treating simultaneously every conceivable variable. It is widely practiced in research and is an acceptable procedure, especially if the validity of the simplifying assumptions is later tested.

On a conceptual basis, emphasis should

§Many readers of AGRICULTURAL ENGINEERING doubtless would prefer to read "farm" rather than "firm" at this point. But as a business enterprise, a farm constitutes a "firm"—or a part of one. Moreover, systems engineering in agriculture may involve different types of farm-related business enterprises as well as farms. Thus the broader category is appropriate.

‖For a more detailed description of this procedure, see French, B. C., Sammet, L. L. and Bressler, R. G. "Economic Efficiency in Plant Operations With Special Reference to the Marketing of California Pears," *Hilgardia*, Vol. 24, No. 19, July 1956, p. 579.

#For support on this point, see Hitch, Charles, "An Appreciation of Systems Analysis," Journal of the Operations Research Society of America, Vol. 3, No. 4, November 1955, pp. 466-481.

be placed on a broad view in systems analysis, part of which involves careful search for significant interdependencies among individual operations and stages. In practice, reasonable assumptions may be sought as to independence, at a practical level, between such components. In this way, the number of possible combinations of alternative techniques that must be considered is greatly reduced. For example, in studies of "plant systems" for packing California fresh pears, this kind of simplification reduced the number of possible combinations from over 14,000 to only 43 combinations requiring comparison of alternative techniques¶. In this case, some obviously minor interdependencies were "factored out." Under some circumstances, this kind of judgment applied to an entire system may indicate effective work to be possible—and perhaps more practicable—if intensive effort is applied only to certain "subsystems" or stages.

In further pursuit of the simplification of systems studies, extensive use may be made of existing engineering design data. Some such data will be available at the outset as standard handbook material and some may consist of standards developed in previous systems studies. Where physical experiment with respect to methods improvement for particular operations is undertaken, attention may be given to the development of data useful in systems analysis. This aspect of simplification would, in fact, be directed toward creation ultimately of new handbook materials as an essential step toward more effective work in this field.

Systems Development

As described above, the major task of "systems analysis" is to describe and define a system and its components, and—largely within the boundaries of known techniques—to specify the optimum technical organization. This indispensable part of systems *analysis* has a counterpart in systems *development* where interest centers on improvement in technique.

In this phase, critical or high-cost operations would be subjected to special study. The procedures of work simplification—well enough known not to require description here—would be applied to such operations to eliminate unessential steps, improve the timing and sequence of operations, devise more efficient work methods, and suggest and develop improved equipment.

The same searching examination would be applied to the system as a whole with the purpose of finding simplifications and new technical bases for improvements in its organization. Still another important aspect of such work would involve consideration of changes in product form or the development of plant or animal strains susceptible to more efficient work methods than those presently available.

An interacting role for systems analysis and systems development is evident in the above. Initially, data for systems analysis are obtained in experimental development and measurements applied to systems components. Systems analysis based on such data may suggest improved forms of organization of the component operations. It may also spotlight operations that are critical for the entire system, and intensive study applied to such points may lead to new techniques and to a new basis for systems analysis.

Team Work in Systems Analysis and Development

Specialization in science and engineering is doubtless responsible to a large extent for recent technological advances in all fields. And these two elements—specialization and expanding technology—are the bases for growth in the development of exceedingly complex man-made systems. They also are making systems analysis and development progresssively more difficult. On one hand, they provide, as well as make necessary, expanded sources of knowledge; on the other hand, they create new problems in communication among specialists. They make it increasingly difficult for an individual worker to acquire the wide range of knowledge and skills required in systems studies or to acquire and maintain a comprehensive view of broad systems problems. This is especially true in agriculture where it is necessary to deal not only with complex equipment systems, but to treat them as essentially complementary to other, perhaps more intricate, natural systems.

These circumstances call for contributions from generalists with capacity and interest in dealing with broad concepts as well as from specialists of narrower orientation, but great depth in particular fields. They point ultimately to the research team as frequently the necessary approach to systems studies. As stated by one authority, "the concept from the engineering standpoint is the evolution of the engineering scientist, i.e., the scientific generalist who maintains a broad outlook. The method is that of the team approach. On problems of large-scale systems, teams of scientists and engineers, generalists as well as specialists, exert their joint efforts to find a solution and physically realize it."**

Having touched on the general aspects of systems analysis and development, thought should be given to several problems of application. Some of these are of special significance in the application of the systems concept in agriculture.

One should first recognize that systems studies are of direct use primarily to individuals responsible for the action or policy decisions of public agencies or private business firms. Business or public enterprises able to participate directly in systems studies usually will be of large scale with responsibility for decision making concentrated and well defined and with opportunity for relatively precise specification in regard to both problem and solution. This scale is achieved in some areas of food processing and distribution. A different situation applies in agricultural production. Here aggregate agricultural industries or commodity groups may be very large. But individual firms, observed trends toward increasing scale of operation by the individual firm notwithstanding, frequently are small. Particularly in agricultural production, the decision makers through whom systems improvement may be realized ordinarily will be individual farm or business owners whose operations are characterized by small-scale, diverse operating conditions and wide spatial distribution. These circumstances hinder the development of results particularized for the circumstances of an individual decision maker. They require that both studies and solutions usually be set in a relatively general framework, one able to provide generalized solutions adaptable to particular circumstances. This—the generalization of solutions and their presentation—is an added challenge common to most lines of agricultural research and development. Its impact is sharper as more complex situations are studied, and so it has special significance in regard to systems studies.

Another important consideration is the reliance necessarily placed on engineering synthesis (or on similar syntheses based on other disciplines) in evaluating alternatives and specifying the optimum system. This draws on the well-established concept of engineering design which is pure synthesis. It is a necessary approach because of the impracticability of subjecting complex analytical models of agricultural systems to practical operational test.

The handicap of being unable to confirm engineering solutions through practical test might, in some circumstances, be eased through presentation of results of synthesis in a probability framework. This step, unfortunately, is not easily accomplished. It would require attention to the variance of estimate for parameters relating to each component in the system synthesis and the development of a statistical framework for reflecting these variances in probability statements concerning the final result. While the latter is perhaps not an insurmountable task, it is not an easy one. Moreover, the requirement of probability estimates of individual parameters may not readily be satisfied. Measurement of labor requirements on specific jobs, for example, would be a major part of most agricultural systems studies and numerous techniques of work measurement are available in industrial engineering for obtaining such data. But the results in industrial applications of these methods generally are not susceptible to statistical evaluation††. This is likely to be true also of their use in agricultural studies. Useful results formulated outside a probability framework are, however, possible, and continued work in this field may ultimately remove this handicap.

Systems engineering needs also to recognize the possible effects of risk and uncertainty concerning future events on optimum choices regarding any system that exists through time. These elements are significant because alternative systems ordinarily will involve choices between different types of equipment involving significant differences in both the magnitude and time span of investment. Risk and uncertainty may thus come to bear in different degrees on alternative systems and so have to be considered in selecting an optimum system.

Risk, if categorized as in economics, is easily disposed of. This is done by limiting

¶*French, et al., op. cit.*, p. 594.

**Goode, Harry H. and Machol, Robert E. Systems Engineering (New York: McGraw-Hill Book Co., Inc., 1957), p. 7.

††For example, Abruzzi, Adam, Work Measurement, New Principles and Procedures (New York: Columbia University Press, 1952), 290 p.

elements so classified to those unforeseeable future adversities for which probability distributions are known. The category may include damage from fire or wind, for example, losses from which are subject to actuarial treatment and are insurable. In economic evaluations of alternative systems, allowance for these factors may be incorporated as insurance costs and thus be permitted to influence choices made among alternative systems.

Uncertainties—again using the economist's classification—include unanticipated future developments for which no probability distribution is known and for which there is no basis for prediction. Such events may include future technological developments in engineering or in the plant and animal sciences which may make existing components technically obsolete, or they may involve future developments that lead to unexpectedly early economic obsolescence of particular agricultural systems. Regarding uncertainty, only limited direct service can be rendered by the analyst. His proper role is confined to solutions based on existing or predictable conditions or in demonstrating the impact of developments that logically may evolve from known or predictable circumstances. Evaluation of uncertainty elements is left to the judgment of the decision or policy maker. But the development of quantitative solutions, even though lacking considerations of uncertainty, narrows the area of reliance on judgment. In this a useful — even indispensable — service is performed by the analyst.

The special problems in regard to practical test of alternative systems, of statistical evaluation of results, and of dealing with risk and uncertainty need not consitute an immobilizing barrier. Useful results may be developed in terms of "best available" single-valued estimates of the values of individual variables or in terms of end results based on ranges in likely values of individual variables. The latter in particular may provide indications as to the range in likely outcomes, and these may be invaluable guides to judgments concerning alternative systems.

Conclusion

There are many different kinds of systems. With some — where control is narrowly centered and interdependence among components very close—there is no escape from systems analysis and design. Systems planning must be comprehensive and complete or there is no performance. With other systems, such as those found in agriculture, components—though interdependent —are more loosely knit together. Such systems frequently evolve through cut-and-try practical experience. They often work—even with a fair degree of success—without broad systems analyses. The motivation for formally organized systems studies, then, may be merely opportunity for improvement in performance rather than compelling necessity.

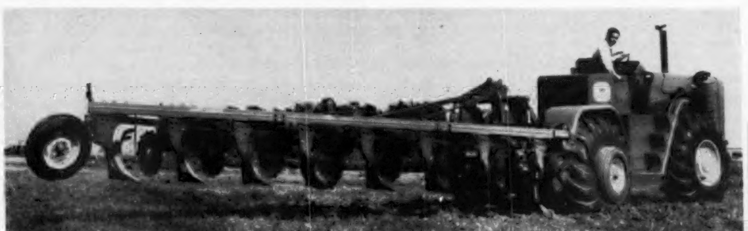
Systems in agriculture frequently, and to a growing extent, do extend beyond farm limits to include closely related services-supply or processing and distribution activities. To an important degree, all these involve the employment and control of structures, equipment, materials, and energy, and so engineering is an important element of their study.

But much more than engineering is involved. As in perhaps no other field, the application of technology from many different disciplines—from the economic, management, plant, animal, and soils sciences to name only a few—is required. Rather than individual or even "cooperative" work, the research team may be a necessary approach. This may cause some concern as to the identity of the central or unifying discipline in such teams. It may even require a new kind of "specialist"—the scientific generalist who is broadly oriented with primary interest in system rather than component performance. A major role of the generalist would be to make the problem to be solved the unifying force in the research team rather than a specialized discipline.

The systems concept involves a most careful search for interrelationships and interdependencies among interacting components. As these relationships are explored, the boundaries of a given system, its complexity, and the difficulties in its study may grow at an alarming rate. This may force a search for simplifications. In this, full advantage should be taken of component flexibility, time lapse between successive operations, or other attributes present in agricultural systems to divide the total system at any point where significant interdependence is not found. Comprehensive systems analysis, with some aid from intuition and judgment, would be used to divide the total problem into segments of manageable proportions or of particular promise for intensive study.

To some, the foregoing discussion may seem only to describe what is done now. This is in part true. The principal change implied is one of emphasis. If current trends in specialization, technological development, and scale of individual enterprise in agriculture continue, greater prominence must be given to functions, processes, and systems as a basic orientation in agricultural engineering.

DEERE ANNOUNCES 10-TON FARM TRACTOR



A RUBBER-TIRED farm tractor weighing 10 tons and matched integral equipment such as a "pickup" 8-bottom plow have been developed by John Deere engineers. The new tractor, equipped with 3-point hitch and hydraulic controls of the type used on conventional farm tractors, reportedly permits use of such huge, integral equipment on farms for the first time.

Power is supplied by a 6-cylinder, two-cycle General Motors diesel which develops 218 hp at 2100 rpm. It has 4-wheel drive with the front and rear wheels mounted on separate units which are coupled together, permitting a turning radius of 17½ ft under full power. The two units can also oscillate independently on rough terrain.

The manufacturer reports that tractors and matched equipment will be produced in time for the 1960 crop year.

Equipment which will be available initially for the tractor, in addition to the 8-bottom integral plow, includes: 18 to 21 ft of offset disk harrow; 31 ft of tandem disk harrow; an 11-ft plowing disk harrow; 3-furrow, 2-way deep-tillage plow; a tool bar with various clamp-on tools including 5 to 7 16-in. chisels, 2 to 5 24-in. panbreakers, 1 to 3 30-in. panbreakers; a 37-ft tool carrier with chisel points and sweeps; a squadron hitch for 34½ to 46 ft of field cultivators; 36 to 60 ft of grain drills and 60 to 72 ft of rod weeders.

1960 NOMINATIONS ANNOUNCED

Nominee for President-Elect

BYRON T. VIRTUE

Nominees for Vice-President

S. M. HENDERSON

T. E. HIENTON

Nominees for Councilor — Electric Power and Processing Division

F. W. ANDREW

J. B. STERE

Nominees for Councilor — Soil and Water Division

R. P. BEASLEY

J. R. CARREKER

Nominations for elective officers of the American Society of Agricultural Engineers for 1960-61 have been reported by the nominating committee, R. K. Frevert (chairman), R. E. Stewart, C. S. Morrison, Nolan Mitchell, and G. E. Spencer. Voting will be by letter ballot to be mailed to voting members in February. Closure of voting will be March 31. Again, during the 1960 election, as part of the transition of reorganization of the Council, offices to be filled will not correspond with vacancies caused by expiration of terms. Three Council vacancies will result from the completion of terms by one past-president, one vice-president, and one councilor. In order that the council be increased from ten to eleven members one president-elect, one vice-president, and two councilors will be elected. The president-elect will serve on the Council one year before his term of office as president. The two councilors will be elected for two years and will be selected as representatives of technical divisions of ASAE. The nominees are as follows:

Nominee for President-Elect

Byron T. Virtue, a native of Iowa, was born March 14, 1908, in Danbury. He also received his formal education in Iowa, graduating from the Mapleton High School in 1925; and receiving a B.S. degree in agricultural engineering in 1931 and an M.S. degree in agricultural engineering in 1932 from Iowa State University.

From 1931 to 1944 he served on the Iowa State University staff in a variety of assignments—research fellowship, extension service, resident teaching, and with the Agricultural Experiment Station. During the years 1944 and 1945 he was connected with Sears, Roebuck and Co. as senior project engineer. He became affiliated with the Torrington Company in 1945 as assistant chief engineer of the Bearings Division. In the years following, he was promoted to chief engineer, Bearings Division; then to general sales manager; and is at the present time vice-president of engineering.

Mr. Virtue has been a member of ASAE since 1932, and served as chairman of the Power and Machinery Division in 1955-56. Also, he holds memberships in the Society of Automotive Engineers, American Society for Engineering Education, the Connecticut Society of Professional Engineers, the National Society of Professional Engineers; and is a charter member and treasurer of the Naugautuck Valley Chapter, Connecticut Society of Professional Engineers. He is a registered professional engineer in the state of Connecticut.

He is also very active in his home-town community, Litchfield, Conn., where he is chairman of board of trustees, First Congregational Church; director, Torrington Rotary Club; served on building committee for three schools; is a member of the Country Club and the Sanctum (a Litchfield men's club). His name is listed in "Who's Who in New England," and "Who's Who in the East."

He was married in 1929 to the former Marjorie Packard, and they have three children — Winifred, who is completing her fifth year of liberal arts and nursing program at Mt. Holyoke College and Hartford Hospital; Mary, who is a junior at Skidmore College; and Kenneth, who is a high school junior. Mr. Virtue has been issued several patents and has contributed technical articles and circulars in extension, research, and other sources. His hobbies include hunting, fishing, woodworking, and furniture repair.

Nominees for Vice-President

S. Milton Henderson, who was born on a farm in Taylor County, Iowa, in 1909, graduated from Simpson College, Indianola, Iowa, with a B.A. degree, in 1932. He earned a B.S. degree in 1939 and an M.S. degree in 1942 from Iowa State University.

He was employed by Ford Motor Co., Detroit, as a chemist from 1933 to 1937 and was associated with USDA, Ames, Iowa, working on research in grain storage, from 1938 to 1943. In the years following (1943-46) he was connected with research in farm structures at Iowa State University. During 1946 and 1947 he was a member of the agricultural engineering staff at the University of Georgia, teaching and doing research in power and machinery. At the present time he is professor and agricultural engineer, Agricultural Experiment Station, University of California, Davis.

Mr. Henderson has been an ASAE member since 1940, and has been active on several committees including: chairman of the Agricultural Process Engineering Committee; chairman of the Committee on Professional Engineering Registration; a member of the Committee on Graduate Instruction; and also the Technical Data Committee. He is at the present time a member of the Committee on Engineering Registration, the Steering Committee of the Electric Power and Processing Division, and the vice-chairman of the Education and Research Division. His honorary fraternal memberships include: Alpha Zeta, Gamma Sigma Delta, Tau Beta Pi, Pi Mu Epsilon, Phi Kappa Phi, Sigma Xi, and Epsilon Sigma. He is also a member of ASEE, as well as being a registered professional engineer. His experience in the writing field is author or co-author of 43 papers and bulletins and one engineering textbook.

Truman E. Hienton was born May 31, 1898, and raised near Independence, Ohio, on a dairy and vegetable farm. He received a B.S. degree in agriculture from Ohio State University, in 1921; a B.S. degree in agricultural engineering in 1926, and an M.S. degree in agricultural engineering, in 1937, from Iowa State University. The professional degree of agricultural engineer was conferred on him by Ohio State University in 1938, and in 1950 Purdue University conferred on him the honorary degree of D.Sc.

During 1918 he served in the U.S. Army. From 1921 to 1923, he was extension agricultural engineer at the University of Nebraska and during 1924 held a similar position at Purdue University. From 1925 to 1941, he was associated with the Agricultural Experiment Station, Purdue University, as leader of farm electrification research activity. He was also, from 1939 to 1941, a half-time employee of the Bureau of Agricultural Chemistry and Engineering. From 1941 to 1946, he served in the U.S. Army as an officer. He took over the duties of his present position as head of farm electrification research in the Agricultural Research Division, USDA, Beltsville, Md., in 1946.

He became a member of ASAE in 1921 and was elected to the grade of Fellow in 1938. His activities in the Society include the chairmanship of the Rural Electric Division (1932-33); member RE Division Steering Committee (1953-56); member, Nominating Committee (1941-42 and 1951-52); chairman of a special Committee on Engineers' Classification in Civilian and Military Service since its organization in 1953. Mr. Hienton represented ASAE on the Policy Committee of Professional Agri-

cultural Societies (1954-57), and also as a member of the Scientific Manpower Commission, American Society of Agronomy and Soil Conservation Society of America (1954-55).

He has been author or co-author of numerous publications including co-author of articles in USDA yearbooks for 1948 and 1952 and senior author of an engineering textbook. He is a Colonel (retired) in the Ordnance Reserve U.S. Army.

Nominees for Councilor —

Electric Power and Processing Division

Frank W. Andrew was born July 15, 1914, near Palmyra, Ill. He graduated from Blackburn College in 1934 with a B.E. degree, and earned B.S. degrees from the University of Illinois in 1938 and 1947.

Mr. Andrew has been on the University of Illinois staff as extension agricultural engineer in farm electrification since 1946. He is best known for his work on automatic feed handling, grain and hay drying, adequate wiring, 4-H electrical project, and his exploits with the automatic tractor in circle farming. He is a charter member of "Flying Farmers" and has logged many hundred thousands of miles in private air travel, mainly for the Extension Service in Illinois. From 1938 to 1946 he was a self-employed farmer, and during this time developed a system of automatic spiral farming, for which he secured a patent.

His membership in ASAE dates back to 1947, and his activity with the Society has been in connection with the Extension Committee, of which he has been chairman and also chairman and vice-chairman of Extension Exhibits.

James B. Stere is a native of Pennsylvania, his birthplace being Fleming and his birth date August 4, 1908.

During the years 1936 to 1938 he held the position of agricultural engineer for West Penn Power Co. In 1948, he became associated with C. A. McDade Co. as an agricultural engineer. He accepted the position of product manager of crop dryers for New Holland Machine Co., New Holland, Pa., in 1955, and is still with the company in this capacity.

He has been a member of ASAE for 22 years, becoming one in 1937. His participation in Society activities have included: Past-president of Pennsylvania Student Branch; past-chairman of the Pennsylvania Section; and past-chairman of Electric Power and Processing Division. At the present time he is a member of the Electric Power and Processing Division's Steering Committee, and a member of the Hay Pelleting Committee.

Nominees for Councilor —

Soil and Water Division

R. P. Beasley, an ASAE member since 1938, was born at Union, Mo., in 1913. He received a B.S. degree in agricultural engineering from the University of Missouri in 1936. After graduation he worked for one year as drainage construction engineer and one year as drainage research engineer for the Bureau of Agricultural Engineering, USDA. In 1938 he returned to the University of Missouri as research instructor in agricultural engineering and received an M.S. degree in 1941. He remained on the University staff until the present time, except for a 3-year tour of duty as a CEC officer in the 56th Naval Construction Battalion in the Pacific theater from 1942 to 1945. Since 1946 he has been in charge of teaching and research work in erosion control, irrigation and drainage at the University.

He is co-author of a textbook on erosion control, and a number of his papers and bulletins on soil conservation and irrigation have been published. He is a member of the honorary fraternity, Sigma Xi, and a registered professional engineer in Missouri.

His ASAE activities include serving as a member of the Nomenclature Committee of the Soil and Water Division; vice-chairman of the Committee on Terrace Systems of the Soil Erosion Group; and past-treasurer of the Mid-Central Section.

John R. Carreker was born on August 15, 1908, in Cooks Springs, Ala. He received a B.S. degree in agriculture in 1930 and an M.S. degree in agricultural engineering in 1933 from Alabama Polytechnic Institute.

He completed a 2-year training course in rural electrification with the Westinghouse Electric and Mfg. Co. in 1932 and served as engineer and later superintendent of CCC camps, doing erosion control work in Alabama in 1933 and 1934. During the years 1934 to 1938 he was agricultural engineer on soil conservation demonstration projects in Alabama. In August 1938, he joined the staff of the Southern Piedmont Conservation Experiment Station at Watkinsville, Ga., as agricultural engineer. He served in that capacity until 1955, when he became station director. In 1958, he was appointed research liaison representative for the Soil Conservation Service and the Agricultural Research Service for nine southeastern states, with headquarters at the University of Georgia, Athens. He is serving in this same capacity at the present time.

He was elected to membership in ASAE in 1931 and in 1955 was made a Fellow. ASAE committee activities and offices held include: Chairman, Georgia Section; vice-chairman, Southeast Section; Committee on Agricultural Hydrology; Committee on Farm Ponds and Reservoirs; Committee on Journal Paper Awards; Subcommittee on Terrace Specification; chairman, Erosion Control Group of Soil and Water Division; Steering Committee of Soil and Water Division; vice-chairman, Soil and Water Division.

Nominees for Nominating Committee:

Electric Power and Processing Division

F. J. Hassler, professor in charge of graduate studies, agricultural engineering department, North Carolina State College, Raleigh. He has been a member of ASAE since 1947; has served as chairman of the Committee on Student Branches; and is presently chairman of the Committee on Graduate Instruction and a member of the Steering Committee, Education and Research Division.

R. W. Kleis, head, agricultural engineering department, University of Massachusetts, Amherst. Since becoming a member in 1950, he has been active in the Connecticut Valley Section; as secretary-treasurer of the North Atlantic Section, and on its Farm Disaster Committee. He has also served on a national basis on the Committee on Feed Handling (chairman); on the Committee on Curriculum and Course Content; the Materials Handling Conference Committee; the Committee on Forward Planning; and on the Steering Committee of the Electric Power and Processing Division. He was also an alternate delegate for ASAE to National Fire Protection Association.

Farm Structures Division

Alvin C. Dale, professor of agricultural engineering, Purdue University, Lafayette, Ind. He became an ASAE member in 1941 and has served the Society as chairman of the Technical Data Committee and as a member of the Committee on Professional Registration; the Steering Committee, the Technical Data Committee, and the Standards Committee of the Farm Structures Division. At the present he is ASAE representative on the ASTM Committee A5.

Dennis L. Moe, head, agricultural engineering department, South Dakota State College, Brookings. He became a member of ASAE in 1948. He is also a member of the American Society for Engineering Education, and Alpha Zeta, honorary agricultural fraternity.

Soil and Water Division

K. H. Beauchamp, irrigation engineer, Engineering and Watershed Planning Unit, Soil Conservation Service, USDA, Milwaukee, Wis., covering the nine north central states. His ASAE membership dates back to 1947, and he has served ASAE as chairman of the Soil and Water Division, a member of its Steering Committee, and committees on Depth and Spacing of Tile Drains (chairman), Surface Drainage, Mechanical Application of Soil Conservation Practices, and Drainage Laws.

John G. Sutton, drainage engineering specialist, engineering division, Soil Conservation Service, USDA, Washington, D. C. He has been an ASAE member since 1927, and served as vice-chairman of the Soil and Water Division in 1956 and chairman in 1957. He was chairman of the Drainage Group for several years, and has held numerous assignments as member and chairman of drainage committees since 1935.

Education and Research Division

F. A. Kummer, head, agricultural engineering department, Alabama Polytechnic Institute, Auburn. He has been a member of ASAE since 1937 and was elected to the grade of Fellow in 1955. His activities in the Society include: Councilor; chairman, Southeast Section; chairman, Alabama Section; and chairman, Education and Research Division.

F. W. Peikert, head, agricultural engineering department, Pennsylvania State University, University Park. Becoming a member of ASAE in 1934, his activities in the Society have included serving as chairman of the Education and Research Division; vice-chairman and chairman of the North Atlantic Section; vice-chairman and secretary of the Michigan Section; numerous other ASAE committees; and currently chairman of the Student Recruitment Committee. He was also chairman of the 1955 Agricultural Engineering Teaching Seminar.

Power and Machinery Division

G. M. Eveleth, chief engineer, Rock Island Works, J. I. Case Co., Rock Island, Ill. He became an ASAE member in 1944, has been active in the Quad City Section, has served as vice-chairman and chairman of the Power and Machinery Division, and has been a member of its Steering Committee. He also has served as ASAE Councilor.

K. L. Pfundstein, manager, agricultural engineering division, Ethyl Corp., Detroit, Mich. He has been a member of ASAE since 1947, and has served the Society as chairman of the Michigan Section; chairman of the Public Relations Committee, and has been active in various other committees.

WINTER MEETING HIGHLIGHTS

E. O. George

E. E. Sweezy

Edwin O. George, vice-president, The Detroit Edison Co., will report on the electric car at the Electric Power and Processing Division luncheon, Friday noon.

Eldon E. Sweezy, management officer and special assistant to the commanding officer and to the technical director of the Diamond Ordnance Fuze Laboratories, the Ordnance Corps' specialized electronic ordnance laboratory, will give the main address, entitled "A Study of Managerial Concepts of Laboratory Type Organizations as Applied to Public Service and Industry," at the Research Committee Open Seminar, Wednesday evening.

Winter Meeting Highlights

The 1959 Winter Meeting of the American Society of Agricultural Engineers will be held December 15-18 at the Palmer House in Chicago, Ill. Registration will begin at 2:00 p.m., Tuesday, December 15. Advance registration cards and hotel reservation forms have been mailed to ASAE members. Non-members interested in attending the meeting should communicate with the central office of the Society at St. Joseph, Mich., for information on accommodations and the program of the meeting sessions. A Cabinet Meeting will be held Tuesday, December 15, at 7:00 p.m. in Exhibition Hall.

Concurrent Sessions

The programs will begin Wednesday morning with five concurrent sessions, which will include Power and Machinery, Program A on the design of machine components, and Program B on models and laboratory methods; Soil and Water on soil erosion; Farm Structures on shelter engineering in hog production; and joint Electric Power and Processing and Farm Structures on crop processing. The five concurrent sessions scheduled for Wednesday afternoon will be: Electric Power and Processing on lighting; Power and Machinery, Program A on tractors; and joint Power and Machinery and Electric Power and Processing, Program B on hay pelleting and wafering; Soil and Water on drainage; and Farm Structures on shelter engineering and management, and storage design.

The subjects to be featured on the five concurrent sessions set up for Thursday morning are: Farm Structures, hot weather shelter engineering, and design improvements for timber frames; Electric Power and Processing, instrumentation and controls; joint Electric Power and Processing and Power and Machinery, Program A, equipment for crop handling and drying; Power and Machinery, Program B, general; and Soil and Water, irrigation.

The Friday morning sessions will be devoted to: Soil and Water on hydrology; Farm Structures on structural frame developments and construction materials and performance; Electric Power and Processing on materials handling; Power and Machinery, Program A on harvesting machinery; and Power and Machinery, Program B on chemical application equipment. The concluding sessions scheduled for Friday afternoon will cover: Techniques for high-speed motion pictures, Power and Machinery, Program A; air conditioning and plastics, Power and Machinery, Program B; pond water treatment, Soil and Water; farmstead engineering, joint Farm Structures and Electric Power and Processing; and electric heating, Electric Power and Processing.

General Session

The General Session, to take place Thursday afternoon, will feature L. E. Grinter, dean of the graduate school, University of Florida, Gainesville, who will speak on challenges and trends in engineering education. The function of the research and development center in my company will be discussed by A. C. Quinn, manager, engineering test department, Tractor and Implement Division, Ford Motor Co., Birmingham, Mich.; W. W. Henning, manager of engineering, Farm Equipment Group, International Harvester Co., Hinsdale, Ill.; and D. R. Wielage, administrative assistant, John Deere Tractor Research and Engineering Center, Waterloo, Iowa. Also featured will be Howard Mold, director of sales personnel, Minneapolis-Honeywell Regulator Co., Minneapolis, Minn., whose subject will be selling engineering viewpoints to the public.

Extension Program

The Extension Program will be held Wednesday evening, and all members working in the area of public agency or commercial extension programs are encouraged to attend this program. Extension methods will be discussed by the ASAE Blue Ribbon winners, which will be followed by a panel discussion on the question "Who's responsible for engineering systems for the farm and why—Manufacturer? Consulting Engineer? Extension Engineer?", with Robert L. Maddex as moderator.

Research Committee Open Seminar

The Research Committee Seminar will be held on Wednesday evening, with Eldon E. Sweezy as the opening speaker, on the topic "A Study of Managerial Concepts of Laboratory Type Organizations As Applied to Public Service and Industry." Mr. Sweezy, under an Army research and study fellowship, explored current laboratory appraisal and control systems, to develop a body of managerial concepts to provide an effective appraisal process for management use. He visited institutions in the United States, Britain, Holland, and Switzerland, and by consultation with research staffs of American universities formulated statements of managerial concepts. His presentation will be based on his findings during the study, and his experience as a research and management administrator. A discussion will follow Mr. Sweezy's address, led by R. S. Davidson, Battelle Memorial Institute, and K. W. Anderson, Deere and Co.

EPP Luncheon

E. O. George, vice-president, The Detroit Edison Co., will be the speaker at the Electric Power and Processing luncheon, scheduled for Friday noon. His subject will be "The Electric Car." Tickets to the luncheon, at $2.00 each, must be obtained in advance (by Thursday night, December 17) from members of the EPP Steering Committee, as the capacity will be limited.

Conference on the 4-H Electric Program

In conjunction with the ASAE Winter Meeting a Conference on the 4-H Electric Program will be held, Tuesday afternoon, December 15. "A Review of the Electric Program Today" will be the subject of a talk by A. V. Krewatch, chairman, 4-H Electric Program Development Committee, and Harold Beaty, University of Illinois, will speak on the electric program and contemporary education. Other topics to be covered are: "Why the National Committee?" and "Plans for the 25th Anniversary." A panel discussion on the topic "What Do We Need?" also will be included on the program.

A-C Farm Equipment Division Plans New Facilities

New facilities for farm equipment engineering development and sales training are being planned by the Allis-Chalmers Manufacturing Co., Milwaukee, Wis., for its Farm Equipment Div., on a 200-acre tract of land along highway 45 about 17 miles southwest of Milwaukee in Racine County. 120 acres of the tract will be used for engineering development and the remaining 80 acres for farm equipment sales training for home office, dealer and field personnel. Two one-story buildings will be constructed; one to house an office and large sales training classroom; the other to include an engineering component test, service, repair area, small machine shop, office and locker room. A test track will also be constructed. Plans also call for the eventual relocation to the new facilities of the test center the company now maintains on W. Cleveland Ave., several miles west of the West Allis Works, in Waukesha County.

J. B. Davidson Scholarship

Thomas L. Hanson, ASAE student member and an agricultural engineering student at Iowa State University, is the first recipient of the J. B. Davidson Memorial Scholarship. It will pay his educational fees for one academic year. He is a senior student in the agricultural engineering department, is married and the father of a son. His interests are in the areas of soil and water, and he expects to continue with graduate study in this area following his graduation next June.

"Engineering Index" Service

World-wide technology is available in "Engineering Index," whose staff reviews every issue of over 1,400 periodicals and society transactions, as well as a large number of bulletins and reports of government bureaus, schools, institutes, and research organizations. For each article reviewed, the following information is printed on a 3 x 5 library card: Subject heading classification, title of article and name of author; name and date of publication; and a brief summary of the article. Subscribers to individual divisions, which include 300 categories, receive all pertinent abstracts once a week. Subscribers to the complete service receive their abstracts daily — about 30,000 cards a year. At the end of each year, all abstracts are compiled into one large, bound volume, completely edited and cross-referenced. Descriptive data and the cost of the divisional listings, as well as the annual volume, may be obtained by writing to: Engineering Index Inc., Engineering Societies Building, 29 West 39th St., New York 18, N. Y.

members of ASAE on the experiment sta-

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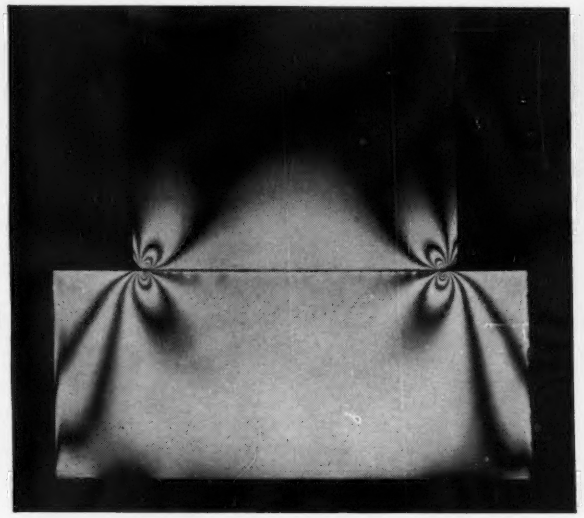
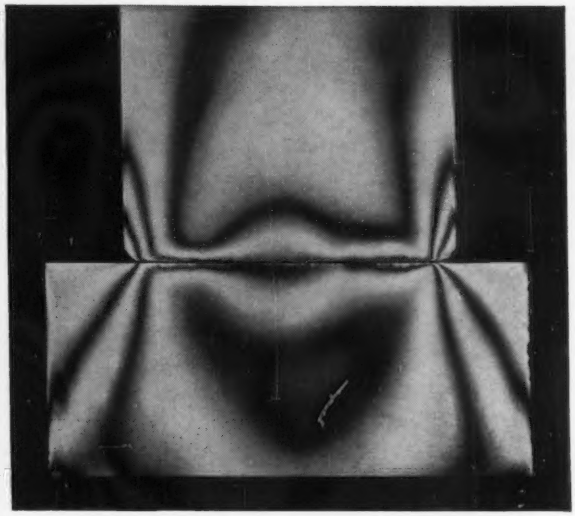
TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

One in a series of technical reports by Bower

BEARING BRIEFINGS

ROLLER BEARING LIFE AND CAPACITY LINKED TO STRESS DISTRIBUTION





These reproductions of photoelastic studies contain important evidence for every engineer and designer concerned with the performance and selection of roller bearings. In these photographs, the alternate dark and light areas, called fringes, indicate not only the magnitude of stress but also the stress distribution. The photographs were taken by Bower Research Engineers during a study of stress distribution in roller bearings.

The subjects represent rollers and raceways of two roller bearings under identical loads. The illustration at the left shows a roller of conventional design. The illustration at the right shows a Bower "Profiled" roller. That is, the roller is precision ground with a large radius generated along the body of the roller—a predetermined and controlled distance from each end.

The conventional roller photo (left) clearly shows how, under load, stress concentration builds up in and near the roller ends. This is called edge-loading. Such areas of concentrated stress are the breeding grounds for metal fatigue and eventual bearing failure.

In the photo of the "Profiled" roller (right) stress lines can be seen uniformly distributed across the whole length of the roller and raceway. There are no points of excessive stress concentration, consequently no starting points for early fatigue. Such a "Profiled" roller exhibits a great advantage in improved load carrying capacity, a most important bearing requirement.

Under actual operating conditions, Bower "Profiled" roller bearings show a considerably longer life at higher speeds and under greater loads than conventional roller bearings.

Because of this, and of other Bower features to be discussed in later technical reports, we suggest that you consider the advantages of Bower bearings in satisfying your future bearing requirements.

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Bower engineers are always available, should you desire assistance or advice on bearing problems. Where product design calls for tapered roller bearings or journal roller assemblies, Bower makes these also in a full range of types and sizes.

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION – FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN

New Experiment Station Building at Wooster, Ohio

For the first time in its 77-year history, the Ohio Agricultural Experiment Station has special facilities on its Wooster campus for research in agricultural engineering, according to Director L. L. Rummell. The newly completed, $500,000 structure was dedicated on October 12 in conjunction with a meeting of the Ohio Section of ASAE.

The modern offices, laboratories and shops provide facilities to study such problems as farm structures, irrigation, drainage farm machinery for planting, spraying and harvesting crops, and farm power. A concerted effort by Ohio and USDA research personnel will be made to solve knotty engineering problems of the farmer. This effort will be made easier since the USDA men, formerly located at Toledo, and the experiment station workers, until now at Columbus, will be housed in the same building. This will make possible the sharing of tools, equipment and techniques.

Heading up the agricultural engineering program is Professor R. D. Barden. Other members of ASAE on the experiment station staff are: W. H. Johnson, associate chairman; Warren L. Roller, J. E. Henry, Glenn Schwab, Kenneth Harkness, B. J. Lamp, and Ronald Hill. USDA personnel to be located at the Station are ASAE members Frank Irons, Orve Hedden, and Ross Brazee.

Location of the engineers next to Williams Hall, the agronomy and forestry building, will permit closer working of engineering researchers with field crops men. A crop processing laboratory will be used for experimenting with drying, grinding, milling, storing, and processing of grains. Big, space-consuming machinery, such as sprayers, combines and tractors, will be housed and tested in a large unobstructed area 64 ft wide by 182 ft long. It is versatile enough to allow a wide range of research to proceed at the same time. Other features of the building include an environmental chamber where grain can be held until tested, a small equipment and components laboratory, an electrical control and instrument shop, a soils and water laboratory and a chemical laboratory.

In connection with the dedication on October 12, the Ohio Section of ASAE held a meeting in the new building. National ASAE President L. H. Skromme spoke at the noon luncheon and also at the dedication ceremonies. Visitors at the Section Meeting were J. L. Butt, executive secretary of ASAE; R. A. Palmer, treasurer of ASAE; W. M. Carleton, Assistant Chief, Agricultural Engineering Research Div., ARS, USDA; and H. A. Bolz, Dean of the College of Engineering at Ohio State University. Nineteen students from agricultural engineering at the University also were present. There were approximately 70 in attendance at the noon luncheon.

New AE Building at Ohio Agricultural Experiment Station

A new agricultural engineering building at the Ohio Agricultural Experiment Station with 27,500 sq ft of space will house offices, laboratories and shops to provide Station agricultural engineers with research facilities on the Wooster campus for the first time since the institution was established 77 years ago.

BULLETIN

As the Journal goes to press word has been received that B. Parker Hess, agricultural engineer, industrial sales department, Westinghouse Electric Corp., East Pittsburgh, Pa., passed away on October 26. Further details will be carried in the December issue.

1960-61 NATO Research Fellowship Program

The aim of the program is "to promote study and research leading to publication on various aspects of the common interests, traditions and outlook of the countries of the North Atlantic Alliance, in order to throw light on the history, present status, and future development of the concept of the Atlantic Community, and of the problems which confront it." A limited number of advanced research fellowships is offered for 1960-61 to candidates from member states. Grants are intended for well-established scholars, and awards will be limited to fellows working on projects of direct interest to NATO or to the Atlantic Community as a whole. Projects should pertain to historical, political, economic and social problems rather than to scientific questions. Applications should be submitted no later than December 1, 1959. Forms and additional information on the NATO Advanced Research Fellowships may be obtained from Conference Board of Associated Research Council, Committee on International Exchange of Persons, 2101 Constitution Ave., Washington 25, D. C.

Agricultural Engineer Status Maintained in Army Classification Changes

Recent changes in Army personnel classifications are covered in new issues of AR-611-211 and AR- 611-212. Several separate classification programs have been combined into one scientific and engineering personnel program. AR-611-211 spells out the operation of the program as applied to in-

(Continued on page 699)

On hand for the dedicatory ceremony for the new agricultural engineering building at the Ohio Agricultural Experiment Station were: *(Left)* left to right, W. M. Carleton, assistant chief, AERD, ARS, USDA; R. D. Barden, chairman of agricultural engineering dept., Ohio State University and head of the agricultural engineering program at the Station; L. H. Skromme, chief engineer, New Holland Machine Div. and president of ASAE; and C. L. Hahn, chairman of the Ohio Section of ASAE • *(Right)* left to right (seated) John Mercer, Ohio Agricultural Experiment Station; W. H. Johnson, assistant professor of agricultural engineering, Ohio Agricultural Experiment Station; (standing) J. P. Ditchman, rural lighting specialist, General Electric Co.; W. F. Keepers, executive secretary, Barn Equipment Association; R. C. Evans, product manager, New Idea Division, Avco Mfg. Corp.; P. G. Strom, director, agricultural extension and market development, American Steel and Wire Division

partment at the University of Tennessee for

Tennessee Section

The 1959 annual meeting of the Tennessee Section was held at the University of Tennessee in Knoxville on October 9 and 10. Sixty-three agricultural engineers were registered.

L. H. Skromme, ASAE president, and chief engineer, New Holland Machine Co., New Holland Pa., headed the list of speakers, his topic being "Let Us Cherish Our Heritage." Other speakers included T. E. Hienton, chief, farm electrification research branch, ARS, USDA, Beltsville, Md. and Robert Rowe, manager, structures and engineering division, Doane Agricultural Service, Inc., St. Louis, Mo. The program theme, "Looking Ahead in Agriculture" was further developed by members of the Tennessee Section. A tour was conducted of the USDA Cotton Spinning Laboratory, U-T Research Electrification Laboratory, and U-T Poultry Housing Research Project.

An important phase of the meeting was a report of the work of the Soil and Water and the Education and Promotion Committees. Jack Liddell, chairman of the Soil and Water Committee, reported that this committee has an important function to perform in assisting the governor's water study group in preparing a report on the Tennessee water situation. Bob Walker, chairman of the Education and Promotion Committee, outlined a three-point plan to increase the enrollment of agricultural engineering students at the University. C. W. Bockhop, head, agricultural engineering department, University of Tennessee, and outgoing chairman of the Section, presided at the business meeting. The highlights of this meeting included a report by Houston Luttrell, chairman of the Sharp Memorial Committee, stating that $500 has been contributed by friends of the late Professor M. A. Sharp, who headed the agricultural engineering department at the University of Tennessee for many years. The sum will be used as a student aid fund to be known as the Sharp Memorial Fund for agricultural engineering students.

New 1959-60 Officers of ASAE Tennessee Section. Shown left to right are: H. D. Sullivan, assistant products engineer, Memphis Works, International Harvester Co., chairman; Curtis H. Shelton, assistant professor of agricultural engineering, University of Tennessee, treasurer; and Jesse Hicks, Soil Conservation Service, Greeneville, vice-chairman.

The 1960 officers unanimously elected are: Herbert Sullivan, International Harvester Co., Memphis, chairman; Jesse Hicks, Soil Conservation Service, Greeneville, and Frank McGregor, Cumberland Electric Cooperative, Clarksville, vice-chairmen; J. A. Mullins, assistant agricultural engineer, Agricultural Extension Service, Jackson, secretary; and Curtis Shelton, assistant professor, agricultural engineering department, University of Tennessee, Knoxville, treasurer.

Quad City Section

The Quad City Section will meet on November 13 at the American Legion Club in Moline, Ill. The program will include talks on new developments in construction equipment, by Elmer Braker, product consultant, Construction Equipment Div., International Harvester Co., Melrose Park, Ill.; and on steel work construction of Moline-Bettendorf suspension bridge, by J. B. Gibson, superintendent, Bethlehem Steel Co., Pittsburgh, Pa. A movie entitled "Taming A New Frontier" will also be shown.

Washington, D. C. Section

On November 13, the Washington, D. C. Section will hold a meeting in Room 6962 of the USDA South Building, 14th and Independence Ave., S. W., Washington, D. C. This will be a noon-time luncheon meeting, and the speaker, H. D. Bouland, structural engineer, Transportation and Facilities Research Division, AMS, will talk on the structures for handling and storing farm products moving in marketing channels.

Pacific Northwest Section

At the annual meeting of the Pacific Northwest Section, in Ephrata, Wash., October 14 to 17, the members voted to include the Canadian provinces of Alberta and Saskatchewan, and the state of Montana into their Section. The new officers elected at this meeting are: R. S. Tait, chairman; Bob R. Andersen, first vice-chairman; James L. Pearson, second vice-chairman; Keith T. Henson, third vice-chairman; Richard D. Appel, fourth vice-chairman; and Leonard M. Staley, secretary-treasurer.

Georgia State Section

The fall meeting of the Georgia State Section is scheduled for Nov. 13 and 14 at The University of Georgia Center for Continuing Education, Athens, Ga. The subjects to be covered during the Friday morning program include: student agricultural engineering co-op plan and activities within the division; the challenge of product development; joint engineering and agronomy demonstrations with farm machinery; precision placement equipment for fertilizer and seed; and deep tillage and deep placement of fertilizer on cotton and corn.

On Friday afternoon the topics to be discussed are: The watershed approach to soil and water conservation, construction of earth dams; the status of peanut irrigation research in south Georgia; results from seven cotton-corn high fertilizer irrigation demonstrations; and an electric program for 4-H summer camping. J. L. Butt, ASAE executive secretary, will be the speaker at the banquet on Friday evening.

The Saturday morning program will include talks on some needs and accomplishments in agricultural engineering research in the Georgia coastal plains and on feed mixing and grinding on the farm for poultry and swine enterprises. The two-day session will be concluded on Saturday morning with a business meeting.

ASAE MEETINGS CALENDAR

December 4 — OKLAHOMA SECTION, Stillwater.

December 16-18 — WINTER MEETING, Palmer House, Chicago, Ill.

January 15—QUAD CITY SECTION, American Legion Club, Moline, Ill.

February 1-3 — SOUTHEAST SECTION, Birmingham, Ala.

March 4 — QUAD CITY SECTION, American Legion Club, Moline, Ill.

March 24-25 — SOUTHWEST SECTION, Washington-Youree Hotel, Shreveport, La.

April 14-15 — PACIFIC COAST SECTION, Arrowhead Conference Center of the University of California.

April 22 — QUAD CITY SECTION, American Legion Club, Moline, Ill.

June 12-16—ANNUAL MEETING, Ohio State University, Columbus, Ohio.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Mich.

EVENTS CALENDAR

November 16-18 — *Structural Clay Products Institute's* Silver Anniversary Convention, Greenbrier Hotel, White Sulphur Springs, W. Va. For further information contact SCPI, 1520 18th St., N.W., Washington 6, D. C.

November 18-20 — Sixth Annual *National Electric Farm Power Conference,* Westward Ho Hotel, Phoenix, Ariz. For additional information write to Inter-Industry Farm Electric Utilization Council, Inc., P.O. Box 577, Washington 4, D.C.

November 19 — *American Grassland Council* 1959 Business Meeting, Sheraton-Gibson Hotel, Cincinnati, Ohio. For further information contact American Grassland Council, Box 30, Norwich, N. Y.

December 2-4 — 46th Annual Convention of the *National Warm Air Heating and Air Conditioning Association, Chase-Park* Plaza Hotel, St. Louis, Mo. Detailed information may be obtained from the association headquarters at 640 Engineers Building, Cleveland 14, Ohio.

December 3 — *Farm Structures Day, University of Illinois.* Details may be obtained from D. G. Jedele, agricultural engineer, University of Illinois, Urbana, Ill.

December 7-11—*Smithfield Show and Agricultural Machinery Exhibition,* London, England. Further details may be obtained from British Information Services, New York Offices, 45 Rockefeller Plaza, New York 20, N. Y.

December 11 - February 14 — *New Delhi World Agriculture Fair,* New Delhi, India. Additional information may be obtained by writing to Farm Equipment Institute, 608 S. Dearborn St., Chicago 5, Ill.

December 14-15 — *Drainage Conference,* Hanford Hotel, Mason City, Iowa. For further details, contact R. L. King, P. E., Mason City Brick and Tile Co., Mason City, Iowa.

December 26-31—*American Association for the Advancement of Science,* 126th Meeting, Chicago. Section M (Engineering) will meet December 28-29. Section O (Agriculture) will meet December 28-31. Contact AAAS, 1515 Massachusetts Ave., N.W., Washington 5, D.C., for additional information.

John D. Cowsar advises he has accepted recently the position of sales manager with P-M Machine Co. of Bryan, Texas. In heading the sales department he will be handling nation-wide sales of the earth-ripper ditching machine and other allied products required by ditching contractors. He previously was associated with American Coin-Meter Corp., also of Bryan, Texas, as operations manager.

J. D. Cowsar

C. K. Kline

J. P. Schaenzer

Cernyw K. Kline, extension specialist in agriculture at the University of Kentucky, advises that he is now located at Bogor, Indonesia, under the Technical Aid Program as a member of a Kentucky Contract Team at the University of Indonesia. His main objective will be to establish a Department of Agricultural Engineering and to develop the new Experiment Station farm which the University of Indonesia has just acquired; it was formerly a large rubber plantation that belonged to the Dutch. He will also do teaching in all areas of agricultural engineering. One of his first jobs is to set up a model farm shop and machinery center.

J. P. Schaenzer, agricultural engineer, Rural Electrification Administration, USDA, Washington, D. C., and his wife have returned recently from a 33-day escorted tour of Europe. They visited Germany, Austria, Lichtenstein, Switzerland, Italy, San Marino, Monaco, France, and England, and took many color slides of the highlights of the trip, as well as others of a rare and unusual nature.

Walter M. Lovett has been promoted to division rural engineer for the Georgia Power Co. and transferred to Augusta, Ga. He was formerly associated with the company's Athens, Ga., plant as a rural engineer.

M. J. Morgan, formerly assistant professor of agricultural engineering at Washington State University, has accepted an International Cooperation Association overseas mission to Khartoum, Sudan.

Jack T. Musick, who has been irrigation engineer at the USDA Experiment Station at Garden City, Kansas, is now associated with the Central Great Plains Field Station at Akron, Colo.

Elmer E. Rigel, formerly an agricultural engineer with the Farm Credit Administration, Salina, Kans., has accepted a position as engineer appraiser for the Federal Land Bank of Wichita, Kans.

Zariel G. Tyson recently has accepted an overseas mission to Sudan. He previously was an associate professor of agricultural engineering at the New Mexico A. and M. College, State College, N. M.

James N. Sherwood, who until recently was electrical adviser for the Whitley Co., Rural Elec. Membership Corp., Columbia City, Ind., is now associated with the National Rural Electric Cooperative Assn. in Washington, D. C., as assistant manager of the power use section.

Richard R. Steingas recently has accepted the position of a design engineer with the Farm Equipment Research and Engineering Center of International Harvester Co. at Hinsdale, Ill. He formerly was a design engineer with Minneapolis-Moline Company.

NECROLOGY

Marlay A. Sharp, retired professor of agricultural engineering at the University of Tennessee, passed away August 26. He was born on a farm near McCook, Nebr., on May 22, 1889. After graduation from the Hebron, Nebr., high school, he entered the University of Nebraska, where he received a B.S. degree in 1915. He earned an M.S. degree from Iowa State University in 1928.

M. A. Sharp

After graduation from the University of Nebraska, he taught in the Winnebago, Minn., high school, from 1915 to 1917; he served in the Naval Air Service in World War I; and he taught for one year in the Minneapolis, Kans., high school (1919-1920). During 1920 and 1921 he was a specialist with the Nebraska State Board for Vocational Education; from 1921 to 1925, he was state supervisor of agricultural education in South Dakota; and from 1925 to 1937 was assistant and later associate professor of agricultural engineering at Iowa State University. In 1937 he became head of the newly-created agricultural engineering department at the University of Tennessee and remained there until 1956, when he resigned that post to become a research and consulting specialist in agricultural engineering for the Tennessee-ICA foreign aid contract at Madras Agriculture College and Research Institute, in Coimbatore, India. He returned to the University of Tennessee on January 1, 1959 and was retired on July 1, 1959. During 1941, he was a specialist in the "war training classes" for the U.S. Office of Education. In 1948, he spent three months in Greece, working on the farm machinery program in connection with the American Mission for Aid. In this same year, he was apponted chairman of a seven-man committee on the Farm Machinery Mission to Europe to survey European Co-operative Administration Recovery Plan Nations.

Mr. Sharp had been a member of ASAE since 1928. He also was a member of Alpha Zeta and Sigma Alpha honorary fraternities; of Mason and Odd Fellow Lodges; and the First Presbyterian Church of Knoxville. He was co-author of two text books on farm mechanics and had also contributed articles to professional magazines.

His survivors include his wife, Winnifred; a daughter, Mrs. Maywin S. Lauderdale; a son, Watson Marlay; and three grandchildren.

George E. Pickard, professor of power and machinery at the University of Illinois, Urbana, died October 3 at Burnham City Hospital, after collapsing at the Illinois-Army football game. Cause of his death was attributed to coronary thrombosis.

G. E. Pickard

Mr. Pickard was born July 14, 1911, in Owen Sound, Ontario, Canada. He received a B.S. degree in agricultural engineering from Saskatchewan University in 1934 and an M.S. degree in 1935 from Iowa State University. He was associated with Massey-Harris Co., Toronto, Canada, for 14 years. For 12 years he was chief engineer for the company in Paris, France. When Germany invaded France during World War II he was sent to a German prison camp.

He came to the agricultural engineering department at University of Illinois in 1949 as an associate professor and in 1951 he was made full professor. During a sabbatical leave in 1956 he was consulting engineer to the Hawaii Sugar Planters Assn.

Mr. Pickard was listed in Who's Who in Engineering and in 1951 was recognized as the most outstanding teacher in agricultural engineering by students in the field. In recent years he had gained fame for working on the adaptation of the combine for picking corn.

He had been a member of ASAE since 1934, and also was a member of the Urbana Presbyterian Church, Urbana Rotary, Sigma XI, Tau Beta Phi, Gamma Sigma Delta and was a registered professional engineer in Illinois.

His survivors are his wife, Dorothy, and a son, William E., with the armed forces in Korea.

Walter L. Brantley, Sr., owner of Brantley Machine Shop in Clewiston, Fla., died on October 23 at his home. He was born November 26, 1891 in Brewton, Ala. A machinist by trade, he was employed for several years by the United States Sugar Corp. in Clewiston, as superintendent of its Western Division shops. Subsequently, he went into the machine shop business for himself, in which he was engaged at the time of his death. He had been a member of ASAE since 1943. His wife, Nellie, survives, as do a son, Walter L., Jr.; a daughter, Mrs. Pearl Stephens, and two granddaughters.

(Continued on page 697)

. . . Necrology

(Continued from page 696)

Aldert Molenaar, a member of ASAE since 1934, died suddenly on September 24 in Rome, Italy, following critical brain tumor surgery. Mrs. Molenaar who lived in Pullman, Wash. received the news by cablegram. He worked with the United Nations Food and Agriculture Organization in Rome and his family had lived with him there part of the time. He had visited his family in July.

A. Molenaar

Mr. Molenaar was born February 16, 1902 in Schagen, Holland. He served for several years as irrigation specialist for the USDA in Washington, D. C., and in the early 1940's was located in Pullman, Wash., as a water utility technician for the USDA. He had also been a staff member at the University of California, as well as the University of Nebraska. In 1947 he joined the Washington State University staff, as a professor in the agricultural engineering department. He resigned his post at WSU in 1951 to become an irrigation specialist with the FAO and his job took him all over the world. He was well known, not only as an irrigation authority, but for his work with students. He spent a great deal of his time helping agricultural students and others at WSU and was particularly interested in foreign students. Several years ago he sponsored an immigrant family from Holland who are now citizens of the U.S.

Mr. Molenaar was an active member of the Pullman Kiwanis Club and the Simpson Methodist Church. Funeral services were held in St. Martinsburg, Holland, near his birthplace. A memorial service was held in Pullman, Wash. He is survived by his wife; one daughter, Barbara; and a son, Richard.

L. M. Roche, western manager of *Electricity On The Farm Magazine,* passed away on July 19. He was born April 16, 1905, in Carrollton, Ill. Mr. Roche joined the magazine staff in July 1929 and was associated with it nearly thirty years. He became a member of ASAE in 1945. His survivors are his wife, one son, and one daughter.

Franklin H. Watson, Jr., agricultural engineer with the East Bay Municipal Utility District in Lodi, Calif., passed away July 4, in a Lodi hospital, after a brief illness. He was born on March 4, 1899 in Biggs, Calif. He graduated from the University of California, College of Agriculture, in 1920, and had been associated with East Bay Municipal Utility District for 28 years. He became a member of ASAE in 1935 and had served as vice-chairman and chairman of the Pacific Coast Section. Mr. Watson was a member of the Lodi Rotary Club, the Woodbridge Golf and Country Club, American Legion Post of Lodi, and the Masonic Lodge of Biggs. He is survived by a son, Franklin H., III, and a daughter, Mrs. Russell B. Adams, Jr., and five grandchildren.

A pick-up type reel is an important contribution to the performance of any harvester — and the design of the right harvester-matched reel is a specialized problem. Why not employ our engineering skill and background to help in this important phase of your overall harvester design? Drawing on our experience of over 25 years and many exclusive patents, we can engineer a pick-up reel tailored to the other design characteristics of your machine, and the crops and areas being served. As a leading producer of pick-up reels, we have the plant capacity and automated production lines to assure you of delivery at reasonable costs. Let us conserve your valuable engineering time.

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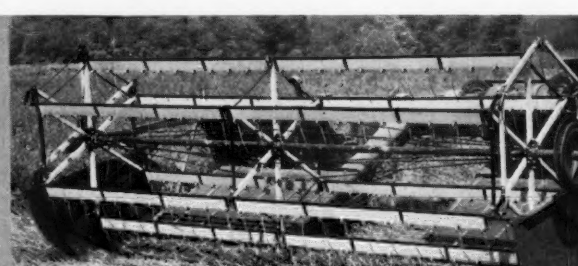


. . . News

(Continued from page 692)

ducted personnel. AR-611-212 outlines the qualifications required and military occupational specialties included in the program.

A previous issue of Army regulations, change 2 of AR-611-211, dated November 13, 1956 identified specific qualifications for a number of scientific and engineering areas, including agricultural engineering. However, AR-611-212, dated May 27, 1959 indicates that graduates in "engineering (all fields)" will be identified and reported.

According to the Dictionary of Occupational Titles (DOT), the existing classification used by the Armed forces, Agricultural Engineering carries the identifying number 0-19.10 which is a sub-heading under 0-19, engineer, mechanical. AR-611-211, dated May 27, 1959, includes the following MOS (Military Occupational Specialty) in the Scientific and Engineering (S&E) Assistants' Program; No. 409 Mechanical Engineering Assistant.

The U.S. Office of Education of the Health, Education and Welfare Department, issues an annual list of "Undergraduate Engineering Curricula Accredited by the Engineer's Council for Professional Development (ECPD)." The list includes those Agricultural Engineering curricula accredited by the ECPD.

To secure appropriate consideration of his qualifications for technical work which may give good engineering experience, an agricultural engineer who is inducted into the Army should be familiar with the Army regulations, the DOT classification, and the Office of Education list. He will find it desirable to have with him a transcript of his credits as this means more to most of the classification personnel concerned than does the term "agricultural engineer."

ASEE Appoints Assistant Secretary

W. Leighton Collins, secretary of the American Society for Engineering Education, has announced the appointment of J. W. Seyler as assistant secretary. In this capacity Mr. Seyler will be responsible for membership, regional activities, and a number of special society projects. The continued growth, and increased activities and responsibilities of the society made it necessary to increase the staff. A native of Illinois, Mr. Seyler received an M.S. degree in Civil Engineering from the University of Illinois, in 1950. After four years of engineering practice, he returned to the University as a staff member, and is at the present time a professor in its Civil Engineering Department.

15th Annual Convention of SCSA

The 15th Annual Convention of the Soil Conservation Society of America will be held at the Ontario Agricultural College, Guelph, Canada, August 28-31, 1960. The program will feature technical and semi-technical papers on the theme: New Technologies in Land Resource Use. Additional information will be found in future issues of the Journal of Soil and Water Conservation. For specific information write: Soil Conservation Convention, Department of Soils, Ontario Agricultural College, Guelph, Canada.

New Power Drive Calculator

The Engineering Division of Atlas Chain & Manufacturing Co., West Pittston, Pa., has developed a new calculator slide rule for computing the proper roller chain for every type of drive. This new slide rule has been developed to supply design engineers and others responsible for specifying power drives with all necessary technical data for the selection of roller chain and sprockets. In easy step-by-step form it covers every factor. Step 1 covers the service factor and design horsepower. Step 2 takes into consideration the horsepower and the number of teeth required in the driving sprocket. Step 3 shows how to select the sprocket size which will accommodate the drive shaft. Steps 4 to 8 include selection data on sprockets. Step 9 shows how to obtain total chain length in "pitches" with charts and actual problems in selecting the proper chain. Step 10 converts length in "pitches" to length in feet or inches utilizing a slide rule.

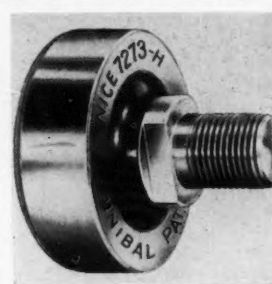
Each of these steps in the application of the right drive is done with a combination of six slide rules made into one large, handy calculator. Requests should be sent on company letterhead to Department C.

Flanged Bearing Units

Stephens-Adamson Mfg. Co., Sealmaster Bearing Div., Ridgeway Ave., Aurora, Ill., announces two new items: three-bolt and two-bolt flange bearing units. The regular "L" bearing cartridge with spherical O.D. is mounted in the one-piece malleable housing providing strength with light weight. Design of the housing permits either flushed or recessed mountings for application flexibility and desired shaft extension with minimum overhang. Full housing contact is also provided under the bearing ball path. Self-alignment takes place automatically between the spherical O.D. of the bearing and the spherical I.D. of the housing. It is claimed the centrifugal-labyrinth seals retain the lubricant and prevent entry of dirt. The flanged units come prelubricated for life and are assembled and ready for immediate service. They are available in standard sizes ¾ through 1⁷⁄₁₆ in.

Plunger Rollers for Balers

Nice Ball Bearing Co., 30th and Hunting Park Ave., Philadelphia 40, Pa., announces development of a plunger roller for balers. The unusual feature claimed for construction of this ball bearing is that it incorporates solid inner and outer races with deep, unbroken ball grooves and a full complement of balls. To combat the unusual amount of dust within the confined space of a bale chamber, a double buna N seal has been incorporated in the design of this bearing, which is claimed to effectively retain lubricant and exclude dust, dirt and moisture. All component parts of the roller and bearing are made of SAE 52100 steel fully hardened to withstand wear.

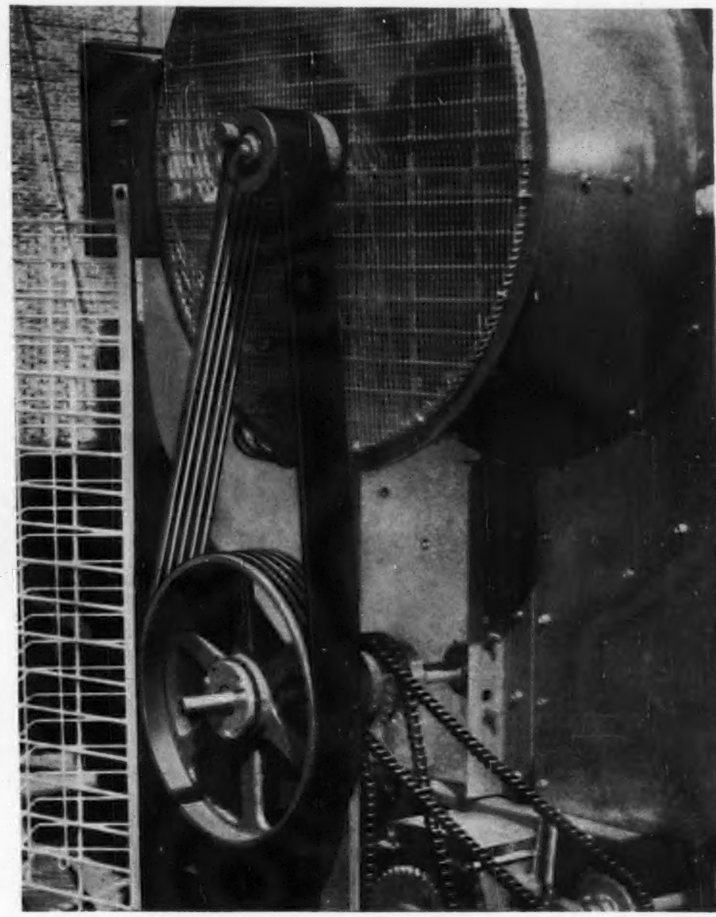


Pole-Steel Building

Inland Steel Products Co., P.O. Box 393, Milwaukee 1, Wis., has developed a new farm and commercial building that combines the advantages of steel with the advantages of the pole barn. Using the basic principles of the common pole barn, the new steel building requires no foundation and is simple to erect. In construction columns are set in holes dug in the ground. Concrete is poured in for stability. Steel rafters and purlins support the roof and wall panels, which are fastened with self-tapping screws. Structural elements are quickly assembled from formed steel sections delivered to the

(Continued on page 702)

R/M AGRICULTURAL BELTS SOLVE EQUIPMENT DRIVE PROBLEMS



On all types of power applications – for every performance requirement – R/M Agricultural Belts have won the confidence of farm machine and equipment manufacturers. For example, by using R/M's patented Poly-V* Drive on the grain-dryer shown above, Behlen Manufacturing Company was able to eliminate the gear reducer formerly required with a V-belt drive to reduce blower speed. Results? A far less expensive power drive installation, longer belt life . . . substantial reduction of vibration on the blower.

On harvesting machines and similar farm equipment drives, engineered features of strength, flexibility and long life built into Manhattan Agricultural V-Belts and Condor Whipcord Endless Belts also assure the day in, day out drive dependability that really pays off on the job! Manhattan belting engineers draw on more than 60 years of rubber technology and experience to help you make your farm equipment drive as trouble-free as possible.

Let Raybestos-Manhattan work with you to solve your power transmission drive problems . . . and show you how R/M Agricultural Belts add "More Use per Dollar" to the equipment you manufacture.

*Poly-V is a registered Raybestos-Manhattan trademark. Patented.

ENGINEERED FOR FARM EQUIPMENT DRIVES

- **R/M AGRICULTURAL V-BELTS**
  Write for Bulletin 6868
- **CONDOR WHIPCORD ENDLESS BELTS**
  Write for Bulletin 6869
- **R/M POLY-V® DRIVE**
  Write for Bulletin M141

"More Use Per Dollar"

RM-901

BELTS • HOSE • ROLL COVERINGS • TANK LININGS • INDUSTRIAL RUBBER SPECIALTIES

MANHATTAN RUBBER DIVISION — PASSAIC, NEW JERSEY

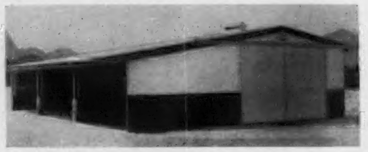
RAYBESTOS-MANHATTAN, INC.

RM

Other R/M products: Abrasive and Diamond Wheels • Brake Blocks and Linings • Clutch Facings • Asbestos Textiles • Mechanical Packings • Engineered Plastics • Sintered Metal Products • Industrial Adhesives • Laundry Pads and Covers • Bowling Balls

. . . New Products

(Continued from page 700)

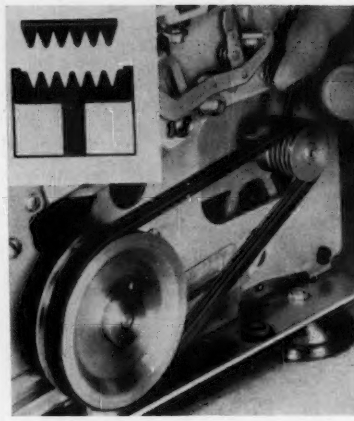


site. All pieces are said to be light enough to be handled and bolted together by one man.

The basic building is a 24-ft clear span, 32 ft long, with eave heights ranging from 8 to 14 ft. To this basic unit, up to six 12-ft lean-to additions may be attached, increasing the width to 96 ft with an eave height of 8 ft. The building may be lengthened by the addition of any number of 16-ft bays. This modular design reportedly makes it possible to combine the various standard units 5,000 different ways.

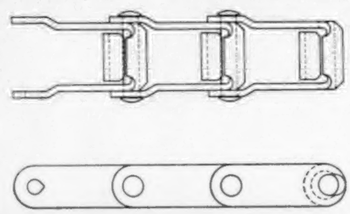
Light-Duty Multiple V-Belt

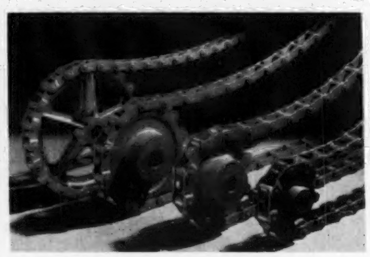
Manhattan Rubber Div., Raybestos-Manhattan, Inc., Passaic, N. J., announces introduction of a new multiple V-belt specially designed for high-speed, small-pulley, power transmission applications. It will operate over sheaves as small as 0.8 in. pitch diameter. Pitch lengths range from 8 to 98 in. In addition to economy of operation, these advantages are claimed for this new belt: requires less space, outstanding performance with small sheaves, quiet vibrationless drive, positive tracking, durable operation, small mounting clearance and takeup requirements, overload slip protection, and good resistance to heat and oil. Descriptive bulletin M142 is available on application to the company.



New Steel Pintle Chain

The Locke Steel Chain Co., 1230 Sabine St., Huntington, Ind., has developed a new type of steel pintle chain, designated as the "600" series, for application on a wide variety of industrial and agricultural machines and equipment. The manufacturer reports that new patented design and automatic forming and assembly methods have made it possible to keep manufacturing





costs low. The new chain is said to be designed for applications where adverse operating conditions, low maintenance requirements, or use with cast sprockets are governing factors. It is produced in four sizes (662, 667, 667-H and 672) to standard steel detachable chain pitches. In addition to the plain steel pintle chain, a number of attachment links are available for use in conveying applications. Complete information on the new chain is offered in a new catalog (No. 60) available from the company.

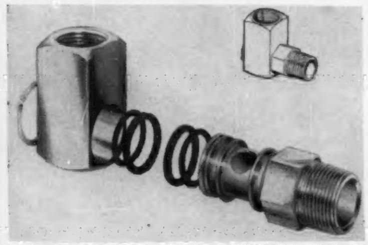
Swivel Connector

Eastman Mfg. Co., Manitowoc, Wis., offers a 90-deg swivel connector which is claimed to be capable of delivering hydraulic fluid at any angle under adequate pressure, and thereby eliminating one of the most common causes of hose failure due to extreme flexing. It is said this connector will "follow" the travel of the equipment

(Continued on page 704)

. . . New Products

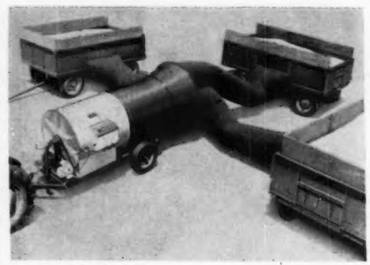
(Continued from page 702)



on which it is used, thereby relieving flexing strain formerly absorbed entirely by the hose. Various combinations of stem for this connector can be interchanged with any body style. Ends which are presently available include male pipe, hydraulic male, "O" ring male, plus solid and swivel female, in sizes ranging from ½ through 1½ in. It is machined out of bar steel and plated for corrosion protection.

High-Capacity Crop Drier

International Harvester Co., 180 North Michigan Ave., Chicago 1, Ill., announces a new high-capacity, transportable crop drier that simultaneously dries and cools wagon-by-wagon without having to shut down the machine. The drier is powered with a power take-off for use with any tractor above two-plow size. It is available



with duct-attaching units for four wagons, enabling the operator to use one wagon in the field while the other three are connected to the drier or with one large duct for drying and aerating corn, grain or hay in the bin, crib or barn. It is built for one-man operation, and it is claimed that it will keep up with the farmer who harvests up to 1200 bu of corn per day. It can also be used to fast-dry chopped hay, sorghum, peanuts, rice, ear corn, baled hay and any grain crop.

Pocket Soil Penetrometer

Soiltest, Inc., 4711 W. North Ave., Chicago 39, Ill., announces its new model CL-700 pocket penetrometer for quickly determining bearing capacity of cohesive soils. The new features include a maximum re-

cording ring on the barrel of the calibrated piston, a direct-reading scale in unconfined compressive strength or bearing capacity in tons per square foot or kilograms per square centimeter, knurled sections on the handle for easy gripping, and a new smaller compact size.

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Bauers, Arthur A. — Proj. engr., Dempster Mill Mfg. Co., Beatrice, Nebr.

Beebe, Raymond A.—Asst. proj. engr., Massey-Ferguson, Inc. (Mail) 19830 Five Points, Detroit 40, Mich.

Berreth, Marvin E.—Des. engr., eng. dept., John Deere Des Moines Works, Des Moines, Iowa

Bigbee, Marvin L.—Engr. trainee, John Deere Des Moines Works. (Mail) 2014 Seventh St., Des Moines, Iowa

Books, Maurice T.—Dev. engr., Danuser Machine Co. (Mail) R.R. 3, Fulton Mo.

Dumas, Raymond A.—Pres., R. A. Dumas Co., Inc. (Mail) 184 S. Main St., Warehouse Point, Conn.

Ellenberger, James R.—Rural rep., Pennsylvania Power Co., Mercer, Pa.

Engle, Henry B.—Farm sales advisor, Atlantic City Electric Co., 7 S. Broadway, Pitman, N. J.

Farrell, Gerald J.—Graduate asst., Iowa State University. (Mail) 2820 L. Way, Ames, Iowa

Ferguson, Henry A.—Proj. engr., John Deere Tractor Res. and Eng. Center, Waterloo, Iowa

French, Ernest W.—Asst. agr. engr., North Dakota Agr. College, State College Station, Fargo, N. D.

Griggs, Grady E.—Area engr., (SCS) USDA. (Mail) 611 Orleans St., Johnson City, Tenn.

Hart, Joe—Sales mgr., irrigation div., R. M. Wade & Co., 1919 N.W. Thurman St., Portland 9, Ore.

Jenkins, G. Willard—Jr. engr., product dev. dept., Deere & Co., Moline, Ill.

Kawashima, Michiyoshi—Asst. prof. of agr. eng., agr. eng. dept., College of Agr. Utsunomiya (National) University, 350 Mine, Utsunomiya, Japan

Lehman, Robert C. — Jr. engr., John Deere Tractor Res. and Eng. Center. (Mail) 1931 Orchard Dr., Cedar Falls, Iowa

Long, Kenneth F.—Vice-pres., Technical Publications, Inc., Div. of Implement and Tractor, 201 Graphic Arts Bldg., Kansas City 5, Mo.

McCormick, Roy S. — Sales rep., Irrigation Equipment Co. (Mail) P.O. Box 163, Wheat Ridge, Colo.

Maha, Arthur E.—Sales mgr., Ball and Roller Bearings Plant, Link-Belt Co., 7601 Rockville Rd., Indianapolis 6, Ind.

Mangold, Duane W.—Instr. and res. assoc. in farm structures, agr. eng. dept., Iowa State University, Ames, Iowa

Merck, James K.—Graduate student, agr. eng. dept., Clemson College, Clemson, S. C.

Miller, Merle L.—Proj. engr., res. des. dept., John Deere Tractor Res. and Eng. Center. (Mail) 421 Cornwall Ave., Waterloo, Iowa

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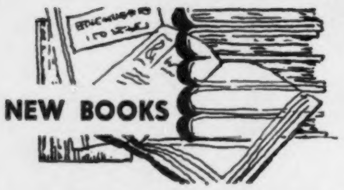


Executive Public Speaking Techniques, by Harry Simmons. Cloth. 8¾ x 5¾ in. XIV + 231 pages. Indexed. Published by Chilton Company, Book Division, 56th and Chestnut Sts., Philadlephia 39, Pa. $5.00.

The book can be described as "a handbook to executive success." Chapters are designed to stress the practical and public relations value of good speaking ability. Section I deals with targets for executives as expressed in questionnaires; Section II is concerned with building the executive's background; Section III itemizes and explains many of the details of modern speaking techniques, with helpful hints, ideas, and suggestions. The author draws from his vast experience to prepare an effective guide to help executives in today's vocal world.

Primer of Lamps and Light, by Willard Allphin, Cloth, 6¼ x 9½ in. XI+241 pages. Illustrated and indexed. Published by Chilton Company, Book Div., 56th and Chestnut Sts., Philadelphia 39, Pa. $10.00.

This book covers: Incandescent, fluorescent, and mercury lamps, and explains how they work and where to use them; light meters, miscellaneous lamp types, and hints on home lighting. Also included is information on how to make lighting calculations and layouts. An added feature is the lighting calculation slide rule for applying the mathematics of the lumen formula. The book should prove useful to lamp bulb salesmen, lighting salesmen, countermen, electrical contractors, students, building maintenance superintendents, electrical foremen, and architects.

Bibliography on Methods for Determining Soil Moisture, by Mark D. Shaw and William C. Arble. Paper. 8½ x 10¾ in. 152 pages. Engineering Research Bulletin B-78, College of Engineering and Architecture, The Pennsylvania State University, University Park, Pa. $2.00.
and thermal.

This survey of literature consists of 629 references to technical papers and patents relating to soil moisture determination and measurement, with abstracts or brief summaries of their content. No attempt is made to evaluate the work or the methods described. References are grouped under the principal methods of soil moisture determination: chemical, electrical, gravimetric, lysimeter, nuclear, penetrometer, tension,

The Statesman's Year-Book 1959, edited by S. H. Steinberg. Cloth. 5 x 7½ in. xxvi + 1673 pages. Indexed. Published by St. Martin's Press Inc., 175 Fifth Ave., New York 10, N. Y. $9.50.

The 1959 edition is its 96th and contains information on topics that should be of interest to statesmen, economists, statisticians, geographers, journalists, teachers, and students. In addition to usual information the book discusses the reorganization of France and the French Community under De Gaulle; Alaska as the 49th state; the organization of the United Arab Republic; latest available material on all the air forces of the world; the railway system of the U.S.S.R. (with reference to the railway system in China, first included in the 1956 edition with a map); and complete revision of material on Latin American countries. Also included are comparative maps of the Panama, Suez, and the Kiel canals; and a map of the Dutch work on the Zuider Zee and Scheldt Delta.

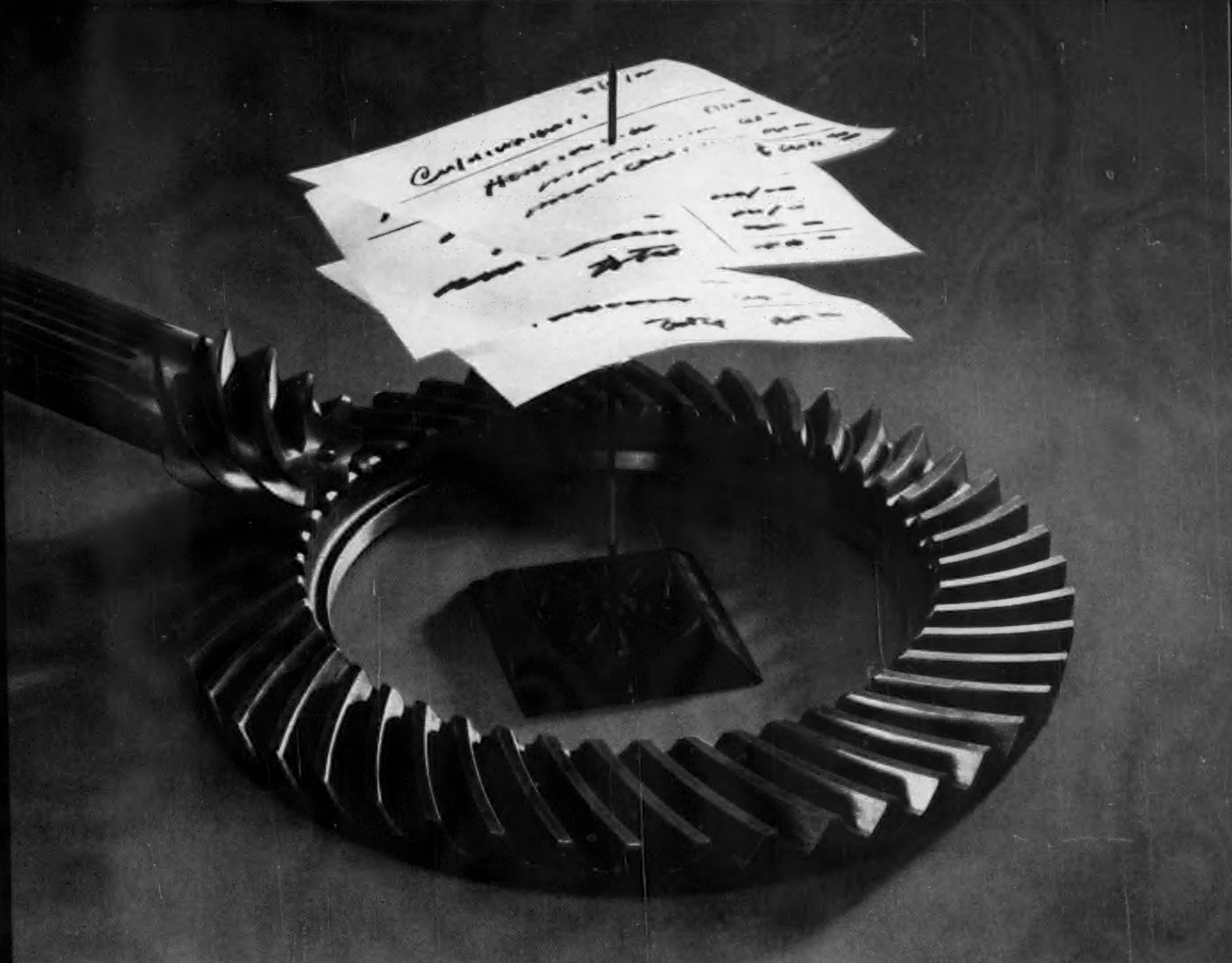
NEW FILM RELEASES

A Sealed System for Haylage. 16 mm, 23 min., color, sound. Produced by Harvestore Products, A. O. Smith Corp. For copy write A. O. Smith Education and Training Dept., Milwaukee, Wis.

A story about two farmers, one on vacation while his neighbor cares for his farm which is equipped with sealed storage and haylage. During the absence of his neighbor he learns about sealed storage and vertical farming and its effect on profit and efficiency.

Quack Grass, the Perennial Guest. Released by the Dow Chemical Co. Available for free bookings to farm groups, schools, and others. Contact Modern Talking Picture Service, 3 East 54th St., New York 22, N. Y.

Agricultural losses to quack grass and the control of this weed grass are explained in this film, which likens quack grass to a burglar who has become a guest by being allowed to remain in farm fields. In crops, quack robs farms of profits through reduced yields, increased cultivation demands and often in decreased quality of crops produced. In sequences filmed in the field, the picture shows the control of this grass in various crops with pre-plant, post harvest or in-crop applications.



MANUFACTURERS' LITERATURE

Literature listed below may be obtained by writing the manufacturer.

Roller Bearings

Rollway Bearing Co., Syracuse 4, N. Y. — A new catalog giving information on the features, applications, and availability of the company's nine principal lines of roller bearings. It describes general features of the bearings and indicates the range of sizes in which they are offered. Included also is a description of the company's manufacturing, research and development, design and testing facilities. Request for copies should specify product-line catalog PL-559.

Chain Drives

Whitney Chain Co., Hartford 2, Conn. — A 6-page folder MSLF 1-59 describing the company's roller chain drives designed expressly for farm machinery, and a roller chain products catalog (RCS 2-58) listing specifications and prices of roller chain products from stock.

Gearmotors, Motogears and Fluid Drives

Link-Belt Co., Dept. PR, Prudential Plaza, Chicago 1, Ill. — A 48-page book (No. 2747) describing the functions of various types of drives with detailed selection data, dimensions, overhung load ratings and mountings. It contains detailed engineering and selection data, with service classifications and application information.

Cog and V-Belt Ratings

Dayton Rubber Co., Industrial Products Div., Dayton, Ohio—Bulletin giving revised cog belt and standard V-belt ratings covering its entire industrial multiple V-belt line. Horsepower ratings of cog belts are now established 200 to 300 percent of previous V-belt ratings. The new horsepower ratings are attributed to improvements in cord materials and construction, rubber compounding, and method of fabricating the belts. The revised ratings are based on extensive field and laboratory tests.

Chain Drive and Conveyor Handbooks

Chain Belt Co., Milwaukee 1, Wis. — Two new handbooks, one on chain drives (bulletin 59126), and one on chain conveyors and elevators (bulletin 59127). Both bulletins are pocket-size editions containing practical information on how to install, operate, maintain and extend the life of chain drives and conveyors, and are well illustrated.

Valve Catalog

Rich Mfg. Corp., Battle Creek, Mich.— New 1959 catalog lists exhaust and intake valves in conjunction with other valve train parts for all 1958 and most 1959 models of passenger cars and trucks, including also industrial and air-cooled engine applications.

Mechanical Counters

Veeder-Root, Inc., Hartford 2, Conn. — A 4-page condensed catalog of the company's standard mechanical counters, including its new high-speed electronic counters. Some of the company's products of its instrument-type counter division are also included.

Plastic Pipe Folder

Marbon Chemical Div., Borg-Warner Corp., P.O. Box 68, Washington, W. Va. — A folder describing plastic pipe for oil field service, irrigation and sprinkler systems, and potable water systems, describing advantages of acrylonitrile-butadiene-styrene pipe.

PERSONNEL SERVICE BULLETIN

PERSONNEL SERVICE BULLETIN

Note: In this bulletin the following listings current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated. "Agricultural Engineer" as used in these listings is not intended to imply any specific level of proficiency or registration as a professional engineer. Items published herein are summaries of mimeographed listings carried in the Personnel Service, copies of which will be furnished on request. To be listed in this bulletin, request form for Personnel Service listing.

Positions Open—May—O-77-914, 49-915, 97-919, **June**—O-124-920, 131-922, 132-923, 135-926, 136-927, 137-928, 140-929, 140-930. **July**—O-170-931, 177-932, 186-933. **August**—O-214-935, 215-936, 217-938, 218-939, 212-940, 220-941, 223-942, 228-943, 228-944, 231-946, 231-947, 231-948, 247-949, 259-950, 259-951. **September**—O-265-952, 219-954, 264-955, 275-956, 285-957, 277-958, 286-959. **October**—O-315-960, 323-961, 323-962, 324-963.

Positions Wanted—May—W-83-15, 84-16, 98-20, 100-22. **June**—W-103-25, 188-27, 112-28, 123-29. **July**—W-154-31, 178-32, 196-33, 190-34. **August**—W-199-35, 210-36, 224-37. **September**—W-249-40, 258-41, 245-43, 267,44, 269-45, 270-46. **October**—W-307-47, 297-48, 321-49.

NEW POSITIONS OPEN

Agricultural Engineer for graduate assistant in research in an eastern land grant university. Choice of technical field within the department. BSAE or equivalent. Academic average for junior and senior years, 2.5 or better. Interest in research and desire to earn MS degree. Position available February 1, 1960. Eleven months duty and one month vacation. Salary $3,024 and tuition. O-327-964

Product Design Engineers (8 or more) for farm and industrial equipment with leading broad line manufacturer in Midwest. Field includes design of tractors, loaders, scrapers, engines, hydraulic systems, and transmissions. Age 21-35. BSAE, BSME, or comparable experience. Prefer men with some design experience in this field. Expansion into new products and modification of established products provides opportunity for advancement to higher engineering echelons. Salary $500-800 per month, depending on experience and ability. O-328-965

Design Mechanical Engineer for work with manufacturer of small power equipment. Would devote time to design of new products and modification of present products, together with necessary field testing. Southeast. Age up to 45. Engineering degree or demonstrated ability to handle the work. Prefer experience in design of gear boxes, together with some production experience. Married, sober, and interested in permanent location in Southeast. Opportunity for broad experience in product design with small engineering department of established, growing company. Salary open. O-341-966

Project Engineer to develop, design, and follow up production of farm grain drills. Design includes writing specifications and repair lists. Upper Midwest. BSAE or BSME. Farm background. Some design experience. General knowledge of grain drills. Honest, clean cut, no physical handicaps. Opportunity for advancement to chief engineer. Salary $425 per month to start. O-320-967

Agricultural Engineer for research in soil and water field with federal agency. Location Southeast. Work as member of a research team on planning and handling approach to problems of improving wet lands of southeastern coastal plain for timber production and other use. Project is cooperative with pulp and paper companies. Will guide large programs of controlled drainage. Age under 35. MSAE or equivalent research experience in soil-water or land management phases of agricultural engineering, including drainage, irrigation, or water management programs. Interest in and capacity for productive research. Excellent opportunity for young candidate for professional advancement. Salary $5280-7510 depending on Civil Service rating. O-346-968

Farm Equipment Engineer for design, improvement and testing of a complete line of hog feeders, fountains, stock tanks, and automatic equipment, with established manufacturer in Midwest. College graduate preferred. Farm background and experience in farm equipment design desirable. Must be able to work with sheet metal. Expanding company offering excellent opportunity for advancement and pay increase for right man. Salary open. O-353-969

Field Promotion Representatives (19) for building material trade association. Promotion through calls on volume construction specifiers including architects, engineers, builders, large industrial users, retail lumber dealers, and jobbers. Also contact building code and governmental agencies. Current openings in 19 widely distributed centers in continental U.S. Men will generally be hired for locations nearest to present residence. Age 27-37. BS in agricultural or civil engineering, industrial design, or forest products, or substantial equivalent in technical understanding and knowledge of structural engineering. Several years experience with emphasis on structures. Neat appearance, good character, able in both oral and written self expression. Genuine interest and potential for honest, aggressive promotion of high quality product. Opportunity for advancement in field department and in fast growing industry up to individual. Salary open. O-352-971

Agricultural Engineers for sales engineering work with distributing subsidiary for manufacturer of metal drainage products and steel buildings. One or more openings in each of 12 divisions in the United States and Canada, to expand operation to develop market potential. Call on engineers in construction field, and other factors in market for drainage products and steel buildings for industrial, commercial, and agricultural use. Age 25-32. BSAE, BSCE, or equivalent, with major in structures option. A few years experience in structures field. Usual personal qualifications for sales engineering. Excellent opportunity in expanding organization. Salary open. O-358-972

Service Manager, to establish a new sales service department. Age 35 to 45, with several years experience as a service manager in farm machinery at the factory or distributor level. Engineering degree desirable, but not necessary if offset by sufficient technical experience. Farm background important consideration. Must have the ability to train factory, distributor, and dealer service personnel. Parts supervision experience desirable. Honest, clean living and integrity essential personal traits. This is an opportunity for the right man to step directly into a key position in our organization. O-361-973

(Continued on page 710)

. . . Personnel Service Bulletin

(Continued from page 709)

Agricultural Engineers (several) for graduate assistantships, all subject matter areas of field. Research program can be arranged to meet individual needs, desires, and capabilities. Northeastern land grant university. BSAE or equivalent, with above average scholarship. Genuine desire for individual study and investigation. Twelve credit hours course work per semester. Openings effective immediately. Salary $2000 plus tuition. O-360-970

NEW POSITIONS WANTED

Agricultural Engineer for extension, teaching and/or research in any combination, in soil and water field, central or eastern U.S. Married. Age 24. No disability. BSAE, 1958; MSAE, 1959, South Dakota State College. Farm background. Summer work on construction. Research assistantship one year. Hydraulic engineer, stream flow analyzer, since receiving MS degree. Active duty for 6 months with Field Artillery to start in February 1960. Available for other employment August 20, 1960. Salary $7000. W-330-50

Agricultural Engineer for sales, service, or management in power and machinery or soil and water field with manufacturer, distributor, farming operation, or trade association. Any location, will travel. Prefer outdoor work. Married. Age 31. No disability. BSAE, 1951, Purdue University. Farm background. Two summers work experience with SCS. Military service 2 years, including 19 months as engineering assistant in research and development on wheeled vehicles, with Army Field Forces Board No. 2. Farm equipment design, 3 years. Currently with well surveying organization on electronic and radioactive logging of test wells for oil exploration. Available on 60 to 90 days notice. Salary open. W-278-51

Agricultural Engineer for design and development of power and machinery, with manufacturer. Any location. Married. Age 33. No disability. BSAE, 1950, Kansas State University. Farm and custom combining background. Design of self-propelled harvester equipment with major manufacturer, 6 years. Lead engineer, mechanical and hydraulic design, with manufacturer of aircraft and missile ground support equipment. Active duty with navy, 2 years. Available on reasonable notice. Salary open. W-284-52

Agricultural Engineer for design, development, research, or writing in power and machinery or product processing field, with manufacturer, eastern half of U.S. Married. Age 27. No disability. BSAE, 1953, University of Maine. Dairy farm background, including owner operator 4 years. High school teacher 4 years. Military service 2 years, Field Artillery. Available on 30 days notice. Salary open. W-335-53

Agricultural Engineer for design, development, research, teaching, or writing, in farm structures or rural electric field, with industry or public service. Any location except Washington, D. C. Married. Age 26. No disability. BSAE, 1956, Iowa State University. MSAE expected 1960, University of Tennessee. Farm background. Research as graduate assistant on effects of plasma discharge on agricultural products, including design, development and testing of equipment, analysis and interpretation of results. Military service in Army 2 years, guided missile research. Available January 1960. Salary open. W-336-54

Agricultural Engineer for design, development, or research in power and machinery with manufacturer. Any location. Southwest preferred. Will travel. Married. Age 22. Wear glasses. BSAE expected January 1960, Southwestern Louisiana Institute. Farm background. Available February 1, 1960. Salary open. W-343-55

Agricultural Engineer for design, development, research, or writing in power and machinery or farm structures field with manufacturer, processor, consultant, farming operation, or trade association. Location South or West. Married. Age 25. No disability. BSAE, 1957, Louisiana State University. Commissioned service in Marine Corps since graduation, as assistant division engineer. Experience in construction, inspection, maintenance, tests, and report writing. Farm background. Summer and part time experience while in college as scale man at rice dryer and elevator, laboratory assistant, and roustabout on offshore oil well drilling operation. Available March 15, 1960. Salary $500-520 per month. W-329-56

Agricultural Engineer for teaching and research in power and machinery, anywhere in U.S.A. Married. Age 29. No disability. BSAE, 1952; MSAE to be completed in June 1960. Farm background. Graduate assistant and instructor while working for MS degree. Available July 1, 1960. Salary $6000. W-363-57

. . . Membership Applicants

(Continued from page 705)

Pal, Jhareswar, P.—Cornelgola, Midnapore, West Bengal, India

Perkins, Roger M.—Asst. spec. in agr. eng., University of California, 2066E Eng. Bldg., 405 Hilgard Ave., Los Angeles 24, Calif.

Reilly, John L.—Sales engr., Hyatt Bearings Div., General Motors Corp. (Mail) 1608 Central Ave., Bettendorf, Iowa

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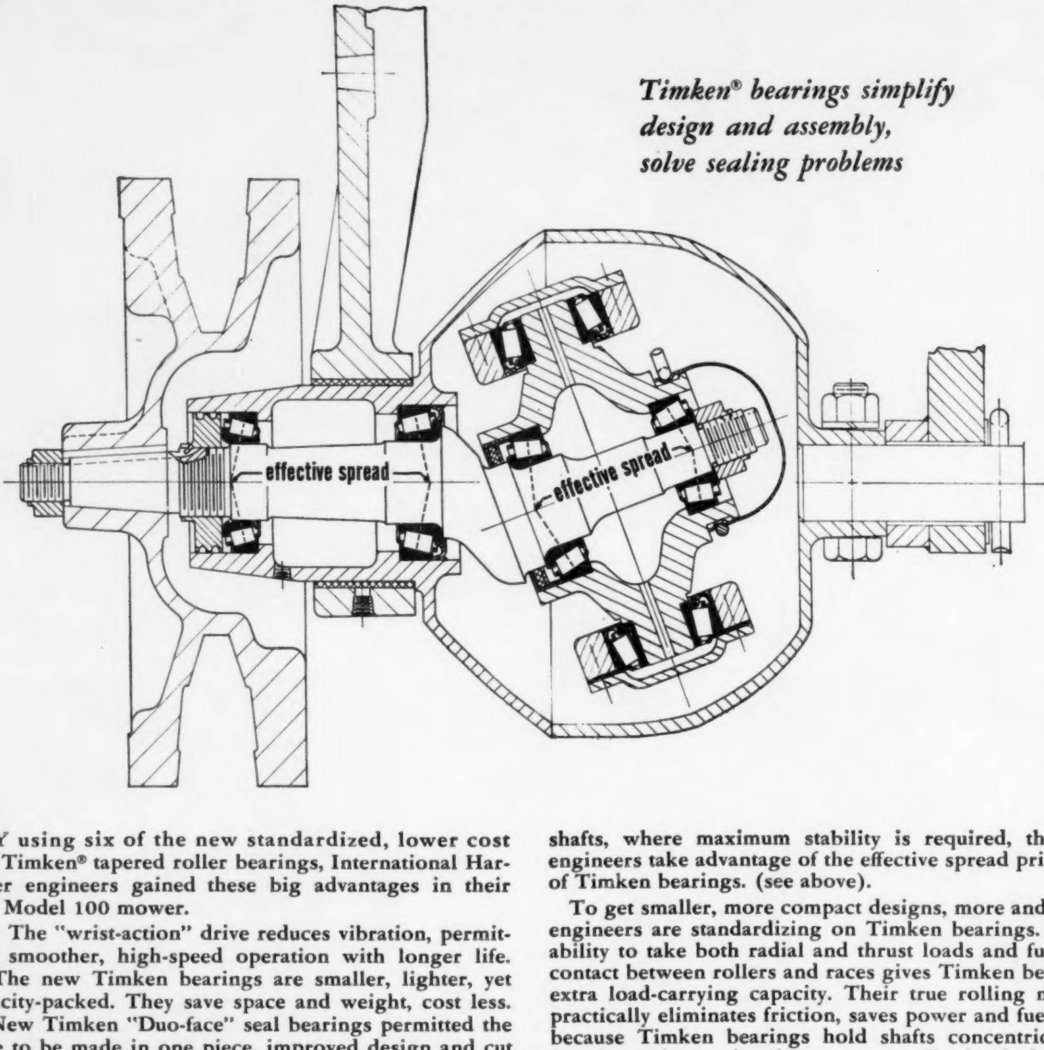
New McCormick No. 100 mower uses wrist-action drive to cut vibration, give smoother operation



Timken® bearings simplify design and assembly, solve sealing problems

BY using six of the new standardized, lower cost Timken® tapered roller bearings, International Harvester engineers gained these big advantages in their new Model 100 mower.

1) The "wrist-action" drive reduces vibration, permitting smoother, high-speed operation with longer life. 2) The new Timken bearings are smaller, lighter, yet capacity-packed. They save space and weight, cost less. 3) New Timken "Duo-face" seal bearings permitted the yoke to be made in one piece, improved design and cut costs. The "Duo-face" gives positive 2-way sealing (face and O.D.). And it cuts installation costs because bearing and seal are pre-assembled.

Timken bearing applications are on the wobble shaft, flywheel shaft and oscillating yoke. Also, in the No. 100 trailing model, the transport wheels are equipped with Timken bearings for fast highway transport. IH engineers pecified the new design Timken "green light" bearings, made by high-speed mechanization, to simplify design and get high load capacity in a small space. And by permitting indirect mounting of the wrist-action and flywheel shafts, where maximum stability is required, they let engineers take advantage of the effective spread principle of Timken bearings. (see above).

To get smaller, more compact designs, more and more engineers are standardizing on Timken bearings. Their ability to take both radial and thrust loads and full line contact between rollers and races gives Timken bearings extra load-carrying capacity. Their true rolling motion practically eliminates friction, saves power and fuel. And because Timken bearings hold shafts concentric with housings, they make closures more effective in keeping dirt out, lubricant in.

Timken bearings enable agricultural engineers to solve three big problems: 1) combination loads; 2) dirt; 3) ease of operation. Farmers get better, more economical machines. For help in designing new bearing applications, call our Sales Engineers. Send for free brochure, "What Timken Company Sales and Service Engineers Can Do For You". The Timken Roller Bearing Company, Canton, 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.*

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER
BEARING TAKES RADIAL AND THRUST LOADS OR ANY COMBINATION

The farmer's assurance of better design

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